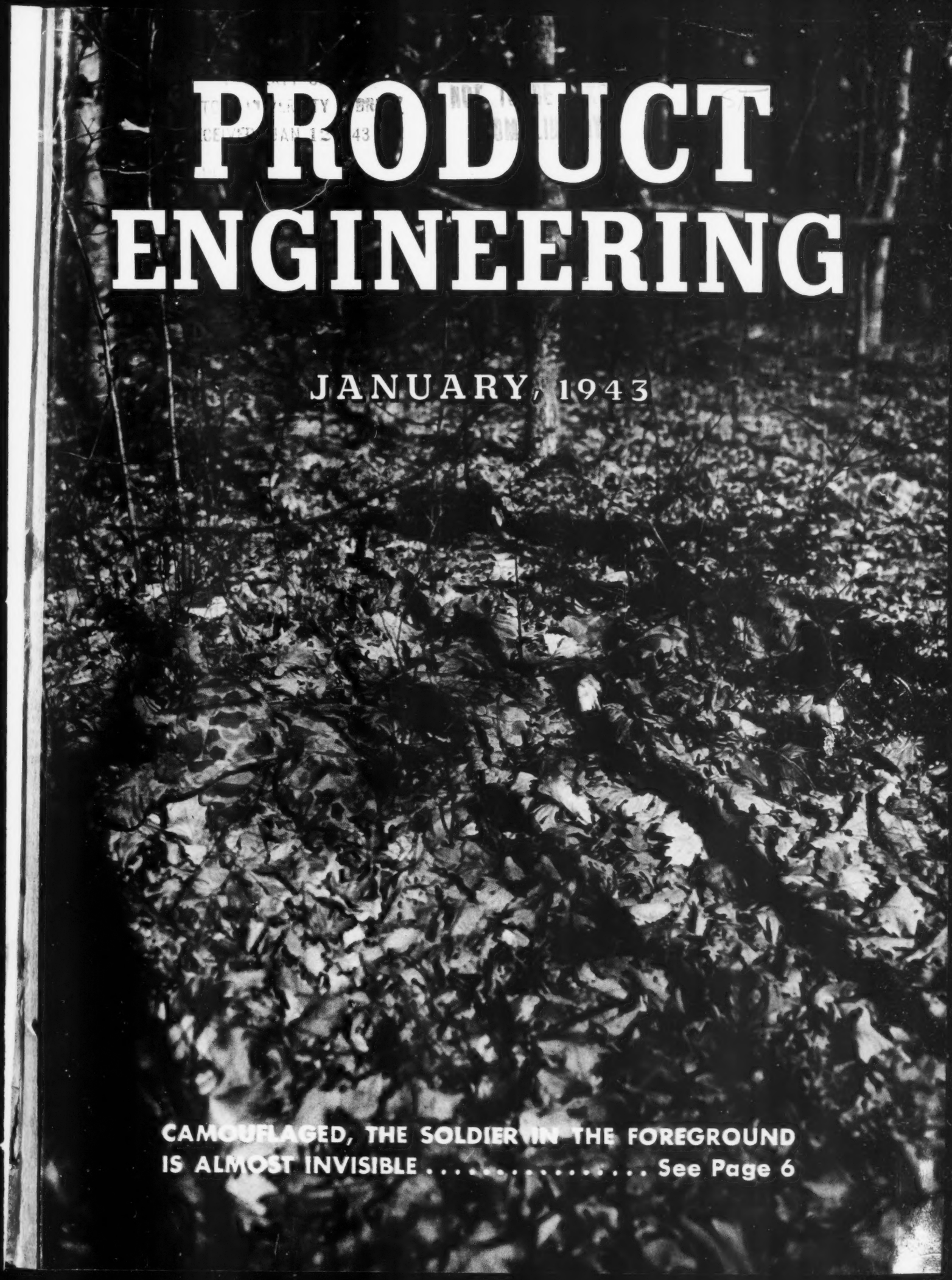
PRODUCT ENGINEERING

JANUARY, 1943



CAMOUFLAGED, THE SOLDIER IN THE FOREGROUND IS ALMOST INVISIBLE . . . . . See Page 6

SEGREGATE YOUR *Scrap*

MIXTURE MEANS LOSS OF CRITICAL ALLOYS

SCRAP salvage is a vital factor in the war effort, and to be fully effective such a program must include methods for segregating and conserving critical alloying elements so urgently needed in the construction of war materials.

Ferrous and non-ferrous metal scrap should be collected in separate containers at the machine where they are generated. Each class of high-speed tool steel and each type of constructional alloy steel should likewise be kept separate so that the alloy content may be returned to service.

Remember,—alloy scrap which is segregated, classified and labeled according to type and composition is a vitally important commodity today—and urgently needed to augment primary supply of nickel, molybdenum, tungsten, etc.

The metallurgical experience of our technical staff is available to aid you in these and other phases of conservation.

KEEP SCRAP MOVING INTO WAR PRODUCTION!

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

Post-War Prospects For Engineering Design

WORKING UNDER THE TERRIFIC PRESSURE OF WAR, America's design engineers have developed noteworthy weapons and tools that are already proving their merit. But the most significant development is still hidden in the research laboratories and in the minds of engineers—a revolution in design techniques and procedures.

Like most revolutions, this one did not come suddenly. Over the past two decades, but more and more intensively over the past few years, engineering design has shifted away from the application of empirical formulas and the rule of thumb. The effects of stress concentrations, fatigue, high temperatures, creep, corrosion and vibration have been more clearly recognized. Tests have been made to determine their importance and effects on various materials. Much valuable information has been accumulated.

Over the same period, new testing instruments and laboratory techniques have been perfected. X-ray, photo-elastic models and brittle lacquers now provide development engineers with powerful tools. Latest is a photo-electric strain gage that amplifies the strain 30,000 times and makes the measurements over a $\frac{1}{4}$-in. gage length.

Skillful engineers are obtaining amazing results with these tools. Many of the concepts of efficient design are being blasted. Strengths are being increased by adding holes or otherwise reducing the volume of metal. Studs are lighter and stronger. Machinery parts are more dependable. Engines have greater horsepower and endurance for their weight—there are many indications that horsepower output per cubic inch of displacement will be increased by about 50 percent within two years.

This tremendous jump in design technology will compel sweeping changes far beyond its effects on product developments. All college-engineering courses will require modifications and lengthening. No longer will it be possible for a young man to spend only four or five years in a technical university and graduate with some kind of an engineering degree. Design engineers of the future will have to reach higher standards. More will be expected of them, for engineering will be placed on a far higher plane. By that token, however, ours will become a more highly valued profession.

WARTIME DESIGN NEWS

S O S CALLING ALL ENGINEERS AND FOUNDRYMEN

Engineers, foundrymen, field service men and others who have information on performance records of cast iron at temperatures in excess of 450 deg. F. can make a valuable contribution to the war effort and to the ferrous industry by contributing their knowledge and experience to the War Metallurgy Committee, National Academy of Science, Washington, D. C. This committee has approved a field research project to study the possibility of utilizing cast iron in elevated temperature operation for the purpose of relieving overburdened industries by encouraging the use of more readily available substitute materials. Time is vital. Detailed information or suggestions as to possible sources of such information, pertinent to the subject, should be sent to either: T. E. Barlow, 2440 Book Bldg., Detroit, Mich., or C. O. Burgess, 4625 Royal Ave., Niagara Falls, N. Y. Information obtained during this study will be reported statistically. Actual details of operation will be kept confidential when desired.

ACCENT ON SHIPS

Significance of the North African front was brought home to eastern motorists November 22 when their gasoline coupons were cut in value from four to three gallons with the explanation that the motor fuel was more valuable in Tunisia. It is being brought home throughout the rest of the country in production shutdowns which must accompany any broad change in the direction of the armament program.

The bald fact is that war production contracts are being and in increasing numbers will be cancelled, with consequent layoff of war workers, while the arms program shifts emphasis from the weapons we have in plenty to those we need. Insiders refuse to guess at the number of contracts, workers or plant facilities which will be affected, but they admit the emphasis has been shifted from tanks and heavy ordnance to shipping, without which all the tanks in the country will never get into the fight.

MAINTENANCE MOVES UP

Priority ratings for repair and maintenance were not all that could be desired during 1942, as the military prepared for the North African attack. Now, as CMP has appeared with its theory of allocation for specific use, be it directly for war or not, the availability of materials for repair and maintenance parts is improving. WPB pointed the way with its ruling that after January 1, ratings of AA-1 will be authorized for materials to allow essential repair and maintenance of productive facilities, housing, utilities and consumer durable goods. When CMP is in operation, you will see specific allocations for repair and maintenance as distinct from production. Until then, necessary repair will be given sufficiently high ratings to get the goods.

COPPER COLLECTION

WPB's copper recovery program, designed to flush idle metal from inventories which contain more than three or four months supply, has reached the "get-tough" stage.

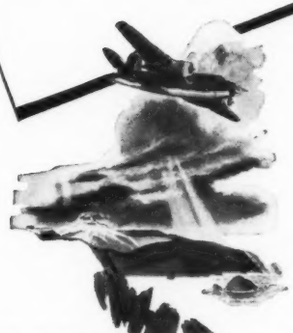
How tough WPB will be forced to get depends on owners; all WPB is interested in is getting the copper. In the first six months of operation, WPB and Copper Recovery Corporation rounded up 138,000,000 lb. which was voluntarily offered for sale. Remainder of the 205,000,000 lb., which was located threatened to come hard, and for that process, WPB lined up a one-two punch guaranteed to bring in the metal.

Those owners unwilling to sell at

U. S. Army Photo

Methods for improving the efficiency and effectiveness of ordnance materiel are being studied in a series of conferences being held by Army officials and industrial scientists. Grouped around this model of a heavy tank used at the second in this series, are Dr. Edgar C. Bain, assistant to the vice-president in charge of research, U. S. Steel Corporation; Dr. F. B. Jewett, vice-president, American Telephone and Telegraph Company; Dr. William D. Coolidge, vice-president and director of research, General Electric Company; Brig.-Gen. G. M. Barnes, chief of the technical division of the Army ordnance department; R. Furrer, vice-president of the A. O. Smith Corporation; Dr. S. Sparre, director, E. I. du Pont de Nemours & Company; C. L. Bausch, vice-president in charge of research and engineering, Bausch & Lomb Optical Company; and Fred M. Zeder, vice-chairman of the Board, Chrysler Corp.

A "point" of Importance



Aircraft of the United Nations are now absorbing a vast amount of the Summerill production of Seamless Tubing. Although our facilities are devoted 100% to the war effort, the services of our engineering and research departments are available to designers and others interested in materials. Experimental lots can be produced.

Before a seamless tube goes to the draw bench, it is "pointed" at one end to provide a short neck of smaller diameter which can be passed through the die and gripped in the jaws of the carriage. This point must be concentric with the tube diameter and should be just long enough to reach through the die. Any excess material forged into the point would represent waste—and loss in length of the finished tube. The men who forge these points take pride in their ability to "point" just enough . . . and no more. These men are, literally, "pointing" for Victory.

This skill and this ceaseless effort on the part of Summerill workmen to maintain production at the highest possible level extends throughout the Summerill organization.

SUMMERILL TUBING CO.
Bridgeport, Montgomery County, Penna.

SUMMERILL TUBING COMPANY

Affiliated with EDGAR T. WARD'S SONS CO. and COLUMBIA STEEL & SHAFTING CO.

OPERADIO

OPERADIO MANUFACTURING COMPANY

St. Charles, Illinois, U. S. A.

Cable Address
"OPERADIO"

Telephones
St. Charles 2300-1-2
Chicago Trunk Mansfield 6446

November 9, 1942

Product Engineering
330 West 42nd St.
New York, N. Y.

Attention: Mr. W. E. Kennedy, Manager

Dear Sir:

The advertising in Product Engineering is a great help and a good source of supply for the latest materials and methods which are necessary in my position of designing various kinds of equipment.

I can assure you and the contributors to this magazine that we have received numerous ideas from reading the advertising and have purchased material from many of your advertisers who have helped us out of many jams that seem to come up during these times.

I wish Product Engineering continued success, keep them coming!

Yours very truly,

OPERADIO MANUFACTURING COMPANY

Albert G. Kautz

Albert G. Kautz
Chief Draftsman

Knee-deep in ARMAMENT design problems, this engineer recognizes the need to read both the editorial and advertising pages of PRODUCT ENGINEERING for "ideas ... methods ... sources of supply."

Now, Here's A REAL Dictator!

WHEN it comes to dictating, the great American consumer has them all beaten! As far as he's concerned, getting the best is very simple.

You just ask for it!

But supplying the best is not a simple matter for the manufacturers on whom this great dictator is casting his shadow—especially in the case of the new products he is expecting as soon as peace is declared.

Automobiles at half the cost, that go twice as far to the gallon! Houses that cost no more than a good car, but with all the conveniences of a palace! Household equipment that will be compact and indestructible! Air conditioning, radiant heating, television, electronic household controls...

And priced so that the average American can afford all of them!

American industrial ingenuity *will* give the consumer what he wants. But it will take revolutionary practices. And often the use of apparently fantastic materials.

Of course the war has brought about the eager testing of every material that research and metallurgy could devise. And many of these substitutes have earned a definite place in the field of metallurgy.

But which material? Under what circumstances? For which specific application?

Revere can help answer many of the questions that beset industry. For just as industry in the future will not be restricted to the traditional materials, neither will Revere. Since the war started, in addition to widening still further the uses for copper and its alloys, Revere has gained wide experience with the light metals, and has developed wholly new kinds of alloys with important properties that can cut manufacturing costs for many industries.

With this great expansion in the range of Revere metals, you can be sure of singularly impartial service from Revere. Today, the copper industry is working all-out for Uncle Sam. No copper is available except for winning the war. But post-war planners with specific problems in metals are referred directly to the Revere Executive Offices in New York.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: 230 Park Ave., New York

Beware of the "Gremlins" that Ruin V-Belt Drives

GREMLINS, those imaginary pixies which infest R. A. F. planes and cause no end of trouble, were invented by the fliers to alibi mistakes, neglect and bad marksmanship.

There are also Gremlins in every plant using Multiple V-Belt Drives. Properly named, they are Ignorance, Neglect and Carelessness. And, they cause incalculable damage to V-Belts at a time when rubber is figuratively worth its weight in gold.

To help power users drive out these destructive forces, the Engineering Research Bureau of the Multiple V-Belt Drive Association has prepared a primer on the selection, installation and maintenance of Multiple V-Belt Drives. This book, "23 Ways to Conserve the Life of Your Multiple V-Belt Drives," is the Association's contribution to the rubber conservation effort and is available without cost tó all who request it.

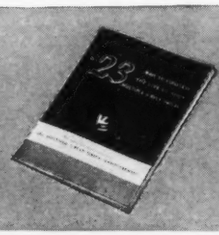
TRADE MARK

The use of this emblem by an association member in connection with Multiple V-Belt Drives is your assurance of mechanical excellence . . . the result of cooperative engineering, research and experience.

MULTIPLE V-BELT DRIVE ASSOCIATION

140 SOUTH DEARBORN ST., CHICAGO

Write for this FREE Association Book Today!



MAN-HOURS SAVED IN SIGNAL CORPS PRODUCTION

The castings at the top and bottom are used in field switchboards (center)

Zinc alloy die castings have long achieved economies in the field of communications. It was quite natural, consequently, that this metal and production method should serve in many ways in equipment for the U. S. Army Signal Corps.

Typical of the zinc alloy die castings employed in field telephone production are the switchboard key frame castings which border the illustration above. Think of the man-hours saved through the ability of the die casting process to provide —as cast—the numerous openings for the keyboard mechanism in these parts! Think, also, of the conservation of machining and assembling facilities!

These savings are measured today in terms of time and man-hours, but they add up to low cost as well. Perhaps this wartime application of zinc alloy die castings provides the key to many of your present and future production problems.

THE New Jersey Zinc ALLOY POT

A publication issued for many years by The New Jersey Zinc Company to report on trends and accomplishments in the field of die castings. Title Reg. U. S. Pat. Off.

PRODUCT ENGINEERING EDITION **No. 5**

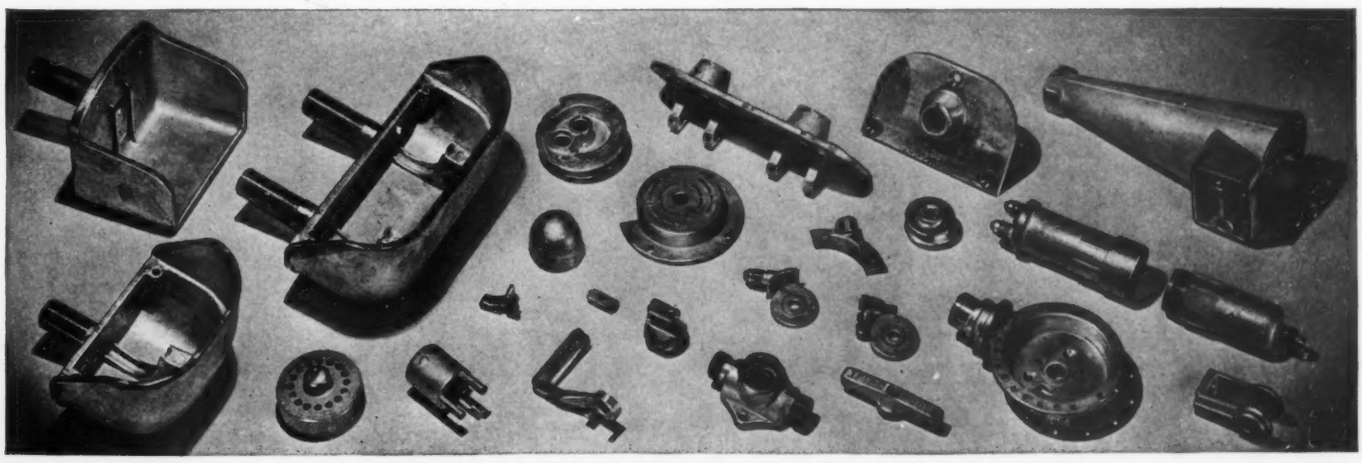
THE VERSATILITY OF ZINC ALLOY DIE CASTINGS

There are many examples of thorough utilization of zinc alloy die castings in producing complicated assemblies. Such strong endorsement of the versatility of this comparative newcomer among high speed production methods and materials occurs in many fields.

The parts illustrated below are particularly up-to-date in this respect because they make up a fire extinguisher assembly used in all U. S. Army tanks. The end-use of this assembly is interesting, but it is the castings themselves which reveal the reasons behind the use of zinc alloy die castings.

Consider these castings in the light of ingenuity of design for compactness—1 part where there would ordinarily be 3 or 4—exacting uniformity for closer fits for operating parts—unusual shapes to utilize every available inch of space.

For additional examples of the advantages of zinc alloy die castings, ask us—on your Company letterhead—for copies of five small booklets illustrating applications in five major consuming fields.



Some of these parts are duplicated in every installation

THE NEW JERSEY ZINC COMPANY
160 FRONT ST., NEW YORK CITY
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

Put Your Screw Driver Army on the DOUBLE QUICK

CUT DRIVING TIME IN HALF!

In today's battle of production, probably more workers are armed with screw drivers than with any other single tool.

Think how many workers in YOUR plant are driving screws . . . and how much time and labor would be saved if you could help them to *drive screws twice as fast!* Chances are you CAN! Hundreds of plants have done just that, by switching to Phillips recessed head Screws.

The scientific centering of driving force in the Phillips Recess eliminates all the handicaps to speed: the fumbling, wobbly starts . . . skidding drivers . . . re-driving of slant-driven screws . . . removal of broken-head screws . . . reclaiming of marred parts. Fast, faultless driving becomes automatic, even for "green hands." Power driving becomes practical for most jobs.

They cost less to use! Compare the cost of *driving* Phillips and slotted head screws. You'll find that the price of screws is a minor item in your total fastening expense . . . that it actually costs less to have the many advantages of the Phillips Recess.

KEY TO FASTENING SPEED AND ECONOMY

The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

Faster Driving – Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

20 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

Plan for a Long War—Work for a Short One!

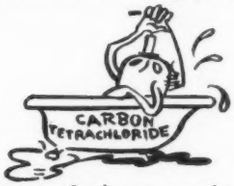
No one can say how long this war will last. But maintenance can say how long America's *motors* will last... and how efficiently they will work to help *shorten* the war!

MAINTENANCE "as usual" went out with Pearl Harbor. Today, every U. S. maintenance man knows he's pitted against a Jap or Nazi maintenance man. He's got a man-sized job...

For example, if the current in a motor exceeds its nameplate current rating, heating may increase as much as the *square* of the current increase! And when a motor runs a fever, there's trouble ahead...

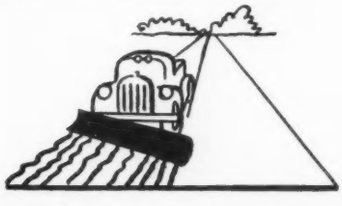
Excessive heat can "fry" the life out of insulation, melt soldered connections, burn out bearings. That's why a close eye must be kept on every motor's overload protection.

Friction is another dangerous source of heat — so the right lubricant in the right amount must be kept *in* bearings and dust must be kept *out!* For cool-running motors, dust must be kept out of *windings*, too...



If compressed air or suction doesn't get the dust out, it's necessary to give the dirty motor a "bath". *Promptly*, too — because the rim travel of a rotor in many motors today is round the world *every eight days*...

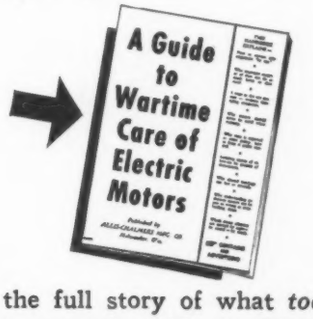
Some job to keep motors rolling at that rate — for the duration!



Just as "rutting" is fought in road maintenance, "grooving" must be fought in *motor* maintenance. Some wear is inevitable on slip rings and commutators, of course. But *smooth and even* wear is *slow* wear!

"Keep oil where it belongs" is a basic rule in maintenance. Once outside bearings, it attacks any insulation it reaches. *Inside* bearings, oil must be protected against misalignment pressures...

The oil film guarding a bearing often is no thicker than the wall of a soap bubble... can fail just as suddenly — *and completely!*

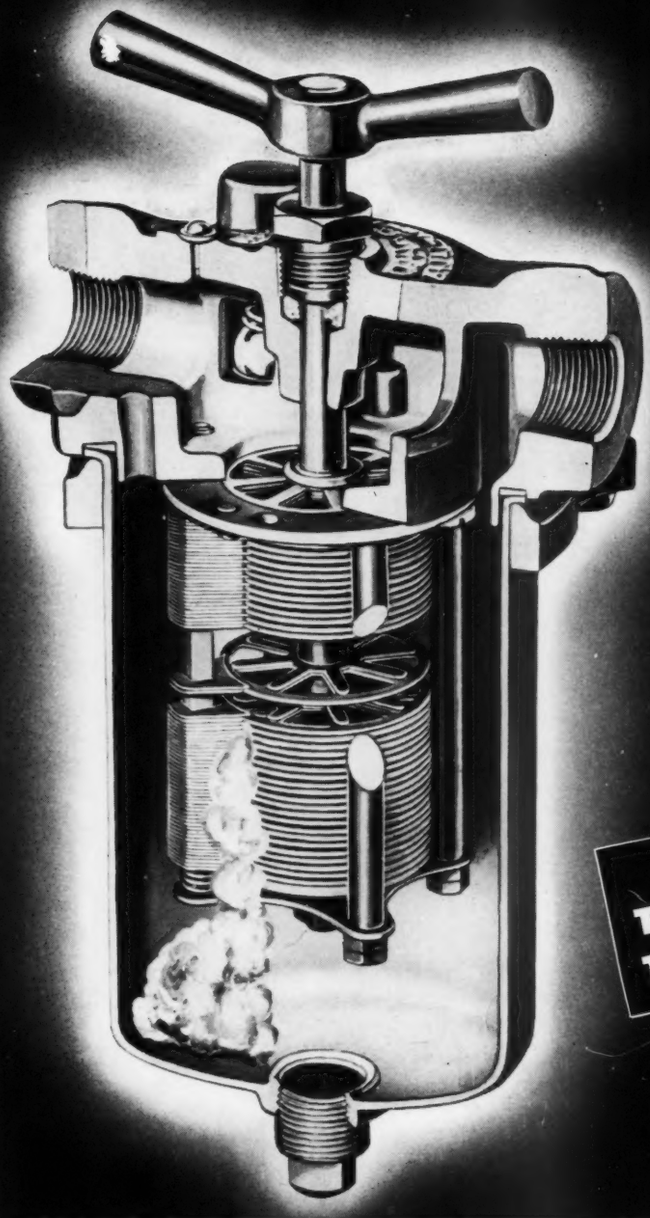


For the full story of what *today's* maintenance should be, send for your free copy of "A Guide to Wartime Care of Electric Motors." It's fully illustrated (with the sketches above and many more), practical, complete. ALLIS-CHALMERS MFG. CO., MILWAUKEE, WISCONSIN.

A 1553

ALLIS-CHALMERS

WE WORK FOR VICTORY — WE PLAN FOR PEACE



CUNO AUTO-KLEAN

Compact and light weight. Mountable externally or unit cartridge may be built into machine.

Non-collapsible filter element will last as long as the equipment on which installed.

Cartridge never needs to be removed for renewal or cleaning.

Cleaned by *combing*, not scraping — which insures *thorough* cleaning (no build-up of sticky residue in slots).

All-metal construction permits use under wide range of pressure, temperature, corrosive and erosive conditions.

Sizes from small lightweight units up to massive motor-driven models.

1

METAL DISCS DO THE FILTERING

The filter element consists of a stack of flat wheel-shaped discs, stamped from strip metal rolled especially to close tolerances for Cuno. Being metal, they are permanent and non-collapsible; nothing to be renewed.

2

DEGREE OF FILTRATION DECIDED HERE

Each disc is separated from the next by a thin metal spacer. The thickness of the spacer determines the degree of filtration. This spacing, specified to meet your particular requirements, may be as fine as .0035″

PUT THEM ALL TOGETHER

YOU'LL GET

This is the part-by-part story of a filter construction that has given aircraft lube and hydraulic systems positive protection against abrasive particles and clogged fluid lines . . . that has helped chemical plants keep fluids in process without delays for filter-cleaning . . . that has provided steel mills, metal-working plants and food processors with a continuous, efficient fluid-cleaning method free from maintenance responsibilities.

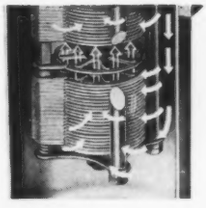
It is the Cuno "Filter-Fine" Strainer — provided in a wide range of sizes and metals to handle all kinds of fluids under a wide range of operating conditions. A simple twist of the external handle cleans the filter element completely. Where automatic filtration is desired, motor driven Cuno filters clean themselves continuously.

3

THE SHAFT IS ROTATABLE

Discs and spacers are mounted in a fixed position on a central rotatable shaft. The "spokes" of these parts are positively aligned so that the open areas between them form channels lengthwise within the cartridge.

5



EDGE FILTRATION STOPS SOLIDS

Fluid from filter inlet surrounds cartridge and is forced by differential pressure to flow radially inward through slots between discs. No solids larger than slot opening can pass. Filtered fluid flows up through central channels to filter outlet.

4

FILTER CLEANED BY METAL BLADES

On a stationary rod paralleling the rotatable stack of discs are mounted knife-like cleaner blades. These blades, slightly thinner than the spacers, extend into the slots between discs as far as the inside edge of disc rims.

6

SOLIDS ARE COMBED OUT

When the cartridge is rotated (manually or automatically) past stationary cleaner blades, all accumulated solids are combed from slots and settle in the sump from which they can be periodically removed.

uninterrupted, *maintenance-free* protection against product contamination or abrasion

NO OTHER STRAINING METHOD OFFERS ALL THESE—

Positively removes all solids larger than minimum size specified.

Imbedded as well as adherent solids positively removed.

Compact — yet full flow capacity.

Practically no pressure loss — only momentary restriction.

Continuous filtration without expense of duplex installation.

KEEP FLOW ON "GO" WITH

CUNO

THE "FILTER-FINE" STRAINER

QUICK FACTS *on Fluid Cleaning*

Send coupon for information relative to *your* fluid-handling problem. Check off applications (or add any other below) which interest you.

CUNO ENGINEERING CORPORATION
301 SOUTH VINE STREET, MERIDEN, CONN.

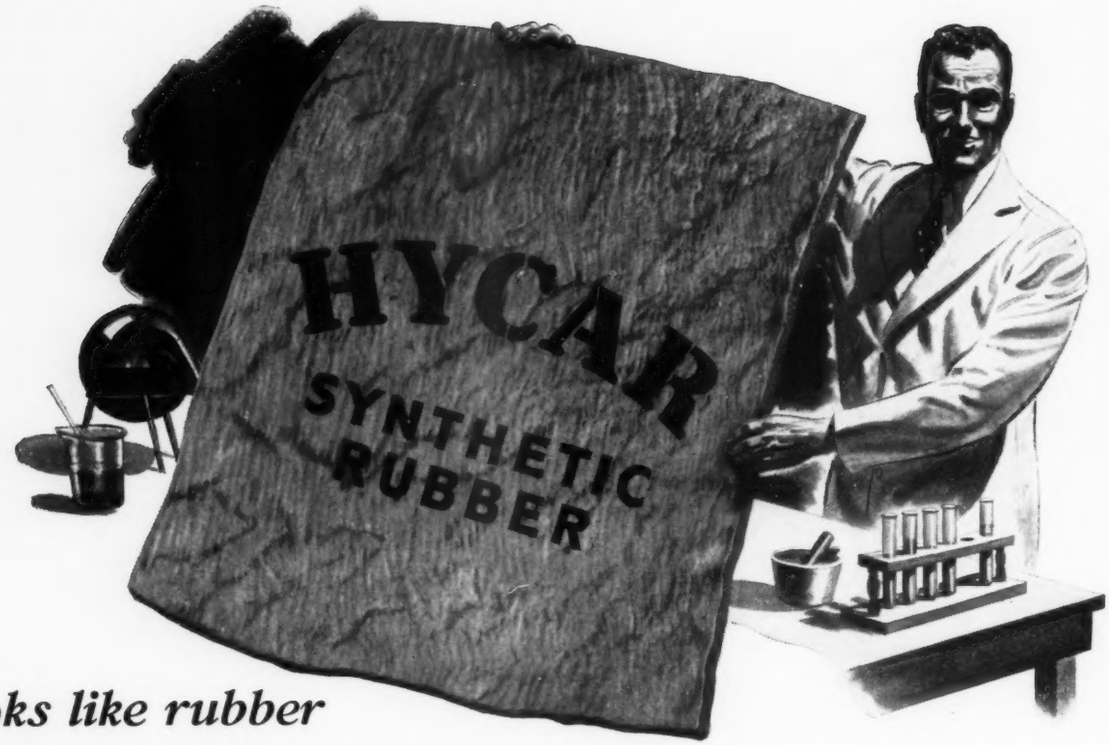
Please send me a free copy of QUICK FACTS. I am especially interested in the services checked.

- ☐ Aircraft
- ☐ Aircraft Engines
- ☐ Air Actuated Instruments
- ☐ Air Tools
- ☐ Bakery Machinery
- ☐ Balers
- ☐ Blowers
- ☐ Boiler Feed
- ☐ Coal Loaders
- ☐ Coating Machinery
- ☐ Combustion Equipment
- ☐ Compressors
- ☐ Controls
- ☐ Cooling Systems
- ☐ Crushers
- ☐ Diesel Engines
- ☐ Dip Tank Systems
- ☐ Drilling Machines
- ☐ Engines
- ☐ Gear Hobbing Machines
- ☐ Grinders
- ☐ Hobbing Machines
- ☐ Honing Machines
- ☐ Hydraulic Systems
- ☐ Incubators
- ☐ Instruments
- ☐ Lathes
- ☐ Lubricating Systems
- ☐ Machine Tools
- ☐ Meters
- ☐ Milling Machines
- ☐ Oil Burners
- ☐ Oil Well Drilling Equipment
- ☐ Paint Spray Systems
- ☐ Paper Machinery
- ☐ Pneumatic Devices
- ☐ Power Transmissions
- ☐ Presses
- ☐ Printing Presses
- ☐ Pumps
- ☐ Radial Drills
- ☐ Rolling Mills
- ☐ Scrap Balers
- ☐ Spray Systems
- ☐ Superchargers
- ☐ Tapping Machines
- ☐ Test Stands
- ☐ Turbines
- ☐ Turret Lathes
- ☐ Welding Machines

NAME .....

COMPANY .....

ADDRESS .....



looks like rubber
acts like rubber—

But... it does things rubber never could do!

America has what it takes to make rubber. We're doing it. We are producing Hycar synthetic rubber, and producing it in quantity in a variety of forms with physical properties controlled. Yes, Hycar rubbers are literally tailor-made for a thousand-and-one different industrial applications.

Some of the superior qualities of Hycar over tree rubber are: Better in strength and electrical properties; greater resistance to deterioration from oxygen, sunlight, and heat. It will stand more flexing—more abrasion. It can be made extremely resistant to oil and most acids. Hycar research laboratories are constantly exploring new possibilities—discovering many improvements.

The big problem today is production in greater volume for planes, pontoons, life rafts, and other war needs. This increased production means that after the war Hycar will continue to replace tree rubber in countless places where it will do a better job and make America a better place in which to live.

Thousands of combinations —and the right one for you

Thousands of different products with hundreds of different properties have been developed with Hycar to meet widely different needs. Many have properties never before thought possible in rubber or any rubber-like material.

Our engineers are at the disposal of your suppliers of resilient materials, to work with them to develop a material with any special characteristics you need.

Hycar is crude synthetic rubber furnished to manufacturers of finished rubber products. If you are producing a war essential, our chemists and engineers will cooperate in determining which type of Hycar rubber will meet your rubber problems. HYCAR CHEMICAL COMPANY, Akron, Ohio.

HYCAR *Synthetic* **Rubber**

LARGEST INDEPENDENT PRODUCER IN AMERICA OF BUTADIENE SYNTHETIC RUBBER

U. S. GOVERNMENT SPECIFICATION FINISHES

". . . a lacquer, air drying, and thinner for oxidized brass eye rims for gas masks . . . shall dry hard within 7 minutes after spraying on a brass plate . . . when sprayed on an eye-ring shall not show abrasion, chipping or peeling when crimped in position . . ."

These are just a few excerpts from a rigid specification required by our government for the metal finish on gas masks. ☆ Our booklet "Information on U. S. Government Specification Finishes," sent free on request, describes the specifications for various types of finishes, and the Maas & Waldstein products which have been developed to meet them. ☆ When new problems arise requiring special finishes, our laboratory will gladly assist you.

MAAS & WALDSTEIN COMPANY, NEWARK, N. J.

PRODUCERS OF LACQUERS, ENAMELS, SYNTHETICS AND SPECIALTY FINISHES FOR ALL PURPOSES

OFFICES & WAREHOUSES: 1658 CARROLL AVE., CHICAGO, ILL. • 1228 W. PICO BLVD., LOS ANGELES, CALIF.

M&W

INDUSTRY'S M

WHEREVER YOU NEED

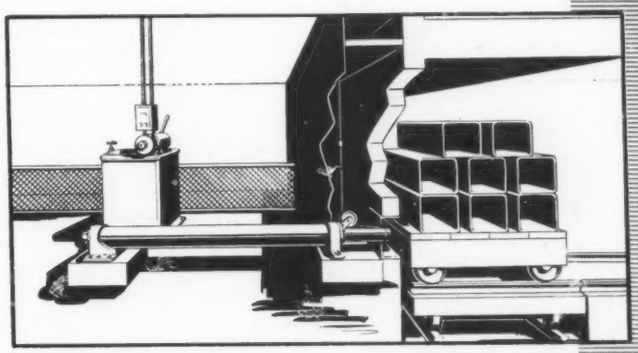
POWER
SPEED
CONTROL

Check

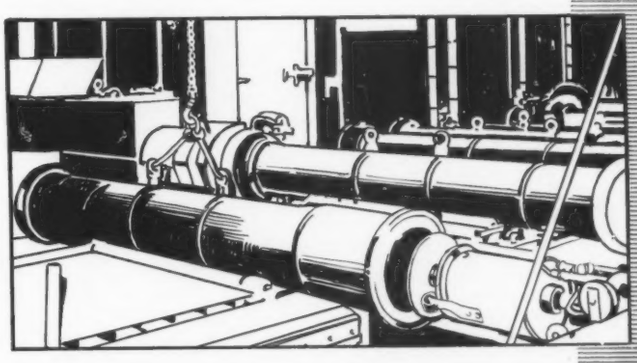
NEW RIGHT HAND

Industry is swinging to a new way of tackling production problems—HydrOILics! . . . an industrial tool that utilizes the basic advantages of oil as a medium for transmitting power and motion.

1. PUSHING operations are one example. In ceramic plants HydrOILic car-pushers ease ponderous, wareloaded cars through tunnel kilns at split-second constancy of speed, regardless of variations in the load. Yet the speed of these car-pushers can be varied to meet exact requirements.

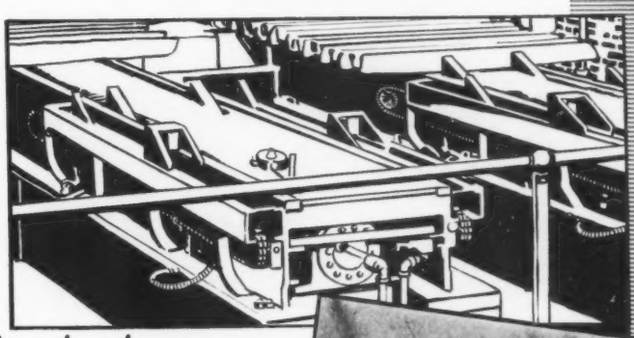


2. On another ceramic job, HydrOILics pushes mixed clay under tremendous pressures through steel cylinders and into automatic machines that form dishes. HydrOILics feeds the clay into the machines at just the right speeds—faster for saucers, slower for plates.



3. In the metal industry, HydrOILic Equipment pushes heavy steel billets through furnaces with the ease of a baker pushing biscuits into an oven.

HydrOILics does jobs like these—and many others—better, because it delivers more flexible power, speed and control. Denison engineers will show you where HydrOILics can improve your production set-up. You won't be obligated by writing; or if you prefer, call your Denison representative.



DATA ON HydrOILic PRESSES!

You'll want this newest catalog on the full line of standard Denison HydrOILic presses. It may point the way to more efficient POWER, SPEED, AND CONTROL on your assembling, straightening, and bending.

EXTRA! Twelve full pages of frequently used engineering tables are also included in this catalog.

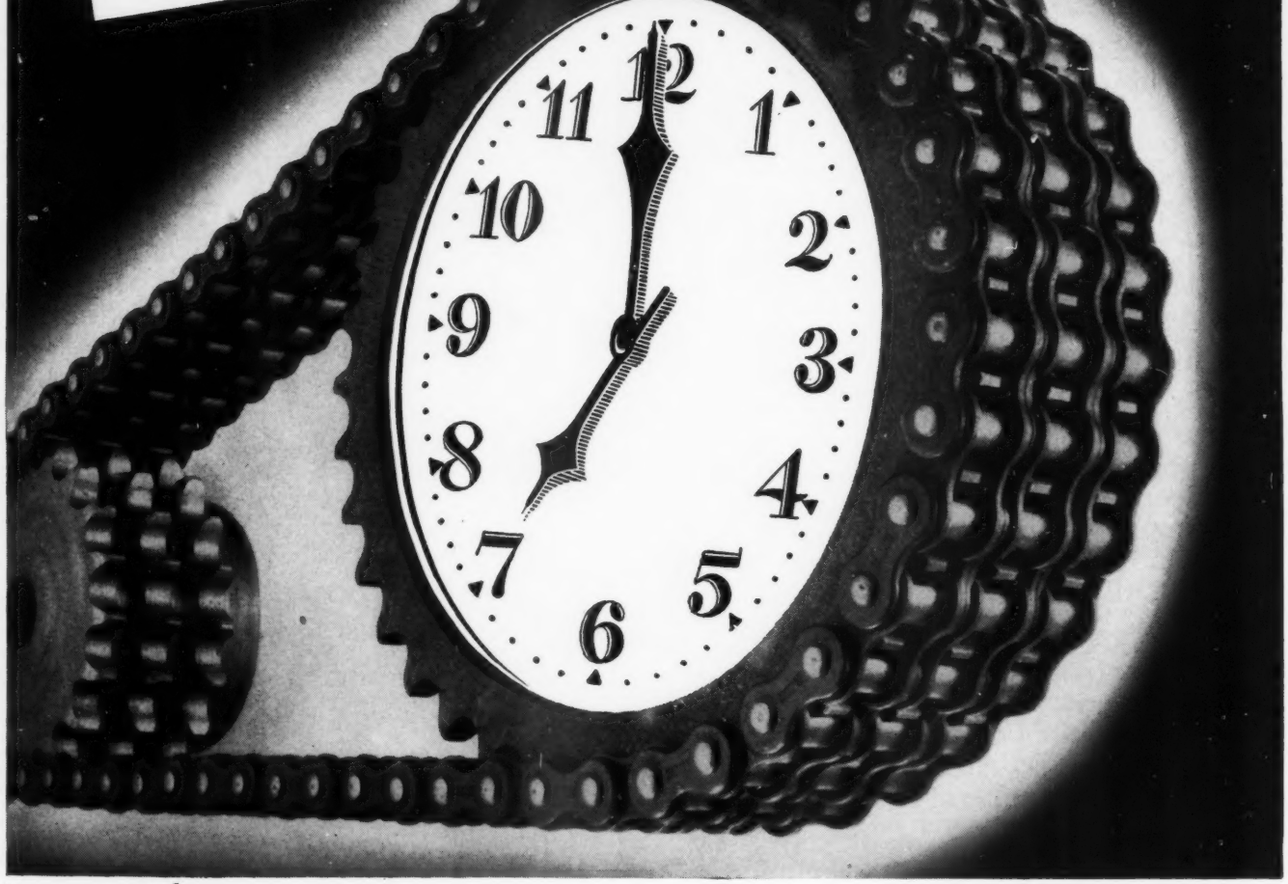
Write today for free copy

The Denison Engineering Co., 1157 Dublin Rd., Columbus, Ohio

DENISON EQUIPMENT in APPLIED HydrOILics TRADE-MARK

Fit Your Machines with WHITNEY CHAINS

...the drives that deliver 24-HOUR POWER



WHITNEY makes the Roller Chains that "run around the clock" ... allowing no slippage ... no variation in speed ... no dip below top machine-capacity. And that's what your customers *must have* in every war-production machine they buy ... positive assurance that the full rated capacity, *which you build in,* will be consistently delivered where they need it. So fit your machines for top performance ... for the duration ... with Whitney Roller Chain Drives.

WHITNEY PRODUCTS *Roller Chain & Sprockets, Silent Chain & Sprockets, Conveyor Chain & Sprockets, Roller Chain Flexible Couplings, Woodruff Type Machine Keys and Cutters*

The Whitney Chain & Mfg. Co., Hartford, Connecticut

Control...

THE CRITICAL FACTOR IN "PRODUCTION LINE" SHIPBUILDING OR STEEL CASTING

In the new "production line" shipyards, vessels slide down the ways at a speed which will make history tragic for the Axis. The swift pace of this new type of shipbuilding is made possible by close control over each step of production.

Control as the critical factor in production for modern war is a principle which has always been strongly emphasized at the Lebanon Steel Foundry. Lebanon neither overlooks nor slights any control step that will promote the soundness and integrity of Circle Ⓛ Castings.

One important Lebanon control operation is illustrated above. The expertly trained inspector is checking a casting for dimensional accuracy. All Circle Ⓛ Castings are given this check-up to see that they correspond to specified dimensions. Wall sections are measured for thickness. Cored areas are thoroughly studied and templates are used to check these areas against blueprints.

Castings of the soundness and integrity demanded at vital points by America's military and industrial forces cannot be produced by short cuts. To obtain Circle Ⓛ quality, Lebanon pays the premium of close control over every phase of production. That's why Circle Ⓛ Castings measure up to the requirements of industries that will not compromise with high standards . . . industries such as Worthington Pump and Carrier Corporation.

Lebanon metallurgists have had close contact with war production requirements since the beginning. Their experience in solving today's type of industrial problem is available to interested organizations.

LEBANON STEEL FOUNDRY • LEBANON, PENNA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* **STEEL CASTINGS**

YOU CAN START *right here!*

to BOOST your output of Stainless parts and REDUCE your Stainless Steel scrap loss!

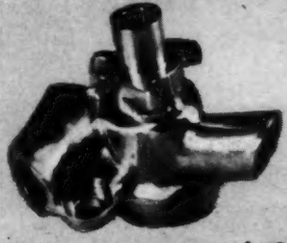
TODAY, there are two big questions in the minds of users of Stainless Steel . . .

"How to increase production of Stainless parts?" and *"How to reduce Stainless Steel scrap loss?"*

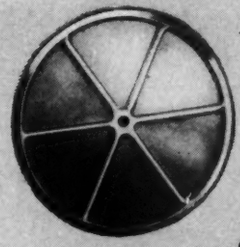
On these pages are useful hints to help you answer both questions. Read them carefully. Use them to help you do a trouble-shooting job in the production of Stainless parts. Add them to your own "know how" that has come from working out Stainless fabricating problems.

These suggestions are a result of the work Carpenter metallurgists and service men have done in many plants where Stainless is used. Much of their experience is now being made available to you in printed form. And through correspondence with the mill, you can get still more help with your specific problems involving the use and fabrication of Stainless Steel.

THE CARPENTER STEEL COMPANY, 117 BERN STREET, READING, PA.

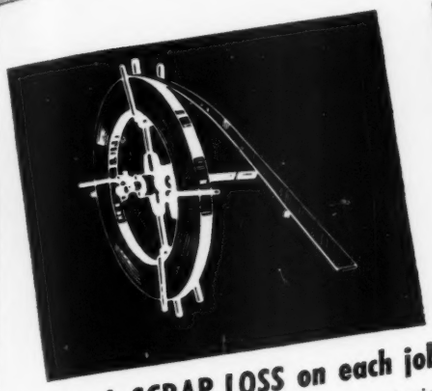


Difficulties in *forging* Stainless Steel fuel supply valve bodies were overcome by making sure that the bars were *thoroughly* heated before the forging operation.



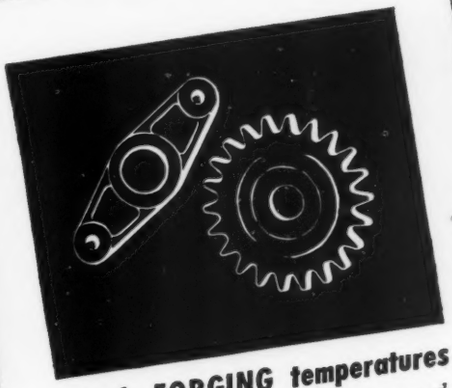
Specifying *narrow* Stainless Strip reduced scrap loss in making this vacuum disc. And the *uniform gauge* of the Strip helped to eliminate production kinks.

more than corrosion resistance



Check SCRAP LOSS on each job

One plant reports a 40% material saving by switching from sheet to Stainless Strip that comes in coils. If you are forming or stamping parts from sheet, find out if a narrow Stainless Strip of the proper width could help you eliminate slitting and the time spent handling sheet.



Watch FORGING temperatures

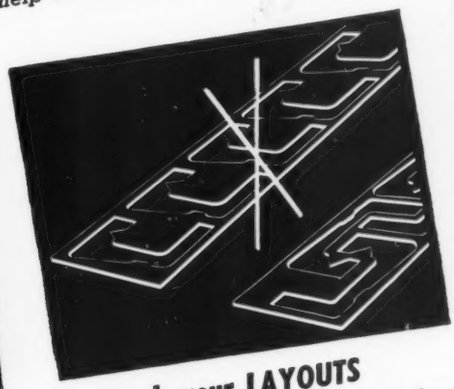
Always run furnaces at the recommended forging temperatures, not hotter. To keep operations going full speed, it may be possible to heat more bars and billets at the same time. Stainless Steels heat more slowly than other steels. So thorough heating of Stainless bars can help to reduce rejects considerably.

CUT DOWN your scrap pile

When rejects are high it pays to gauge your stock. Material that is not uniform throughout may be the answer to a high percentage of rejects. Undersize material can cause wrinkling in the die. Tearing and galling can result from using oversize material. Gauge your stock for answers to fewer rejects!

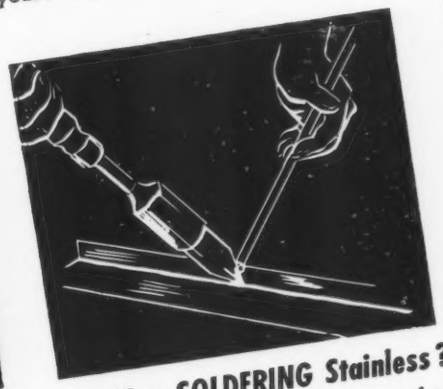
When HEAT TREATING Stainless

. . . be sure that all Stainless parts are absolutely clean—free from any grease or foreign matter—before putting them into the furnace. This will help you avoid excess scale, and cut pickling time to a minimum. And remember that medium or heavy sections should be soaked at the hardening temperature.



Re-check your LAYOUTS

Another way to conserve Stainless Steel is to re-check layouts on jobs that are stamped from Stainless Strip. The results will be well worthwhile, in terms of metal conserved and time saved. In some plants, skeleton scrap losses on stamping jobs have been reduced by as much as 20%.



Are You SOLDERING Stainless?

If so, remember that heat is absorbed more slowly by Stainless. Thus, a larger and heavier iron should be used. It is not necessary that the iron be hotter, just larger with more heat capacity to allow the solder to flow more freely. Thorough cleaning of the Stainless surface before soldering is a must!

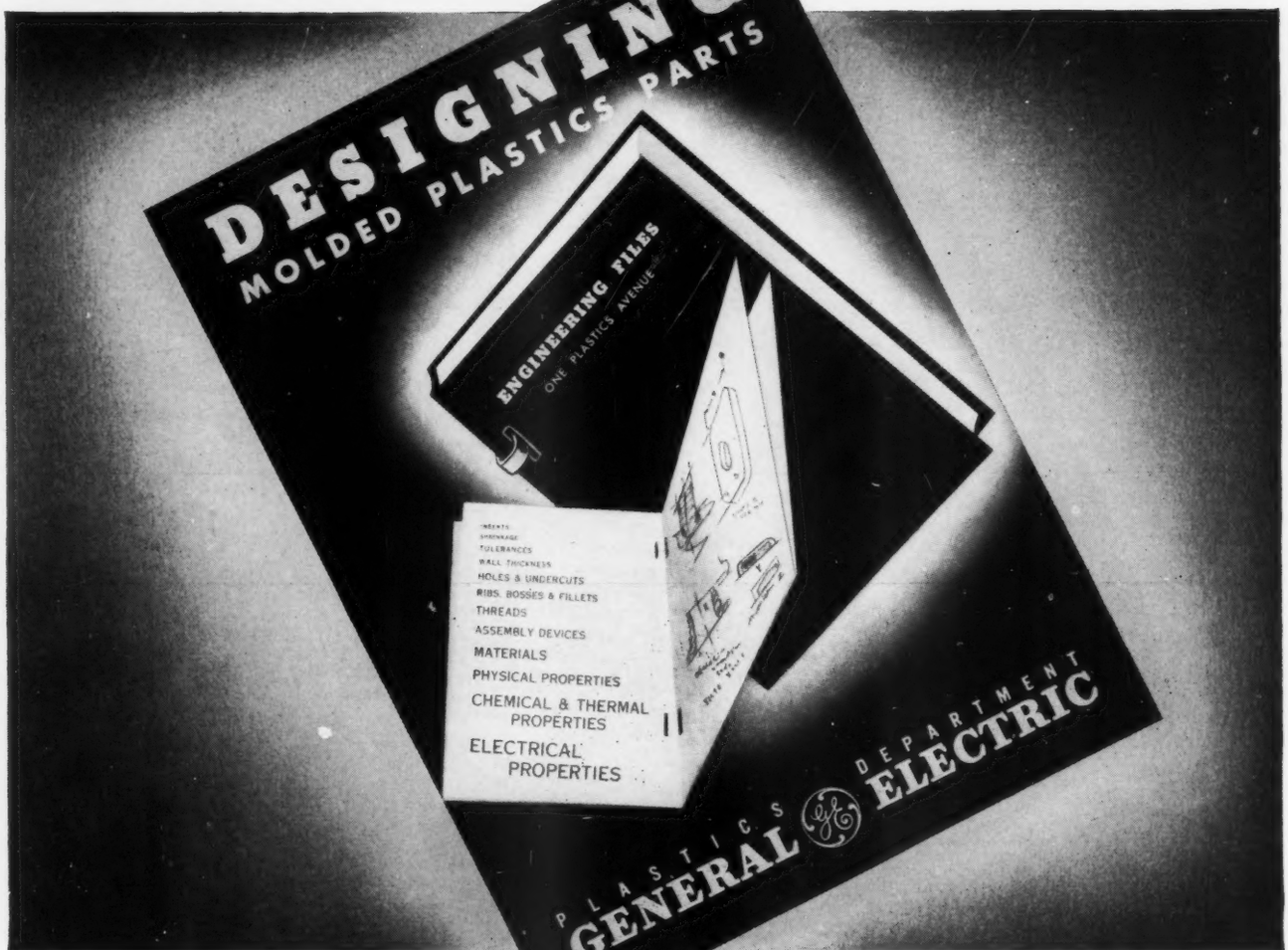
Here is practical engineering information to help you get the most from every pound of Stainless Steel. This 98-page book, "Working Data for Carpenter Stainless Steels", contains helpful fabricating hints. It can provide you with detailed data about Stainless Steels to meet government specifications and to solve heat or corrosion resistance problems.

This Working Data book is available to users of Stainless Steel in the U. S. A. If you would like the "know how" information it contains, a note on your company letterhead will start a copy on its way.

Carpenter STAINLESS STEELS

BRANCHES AT Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, New York, Philadelphia

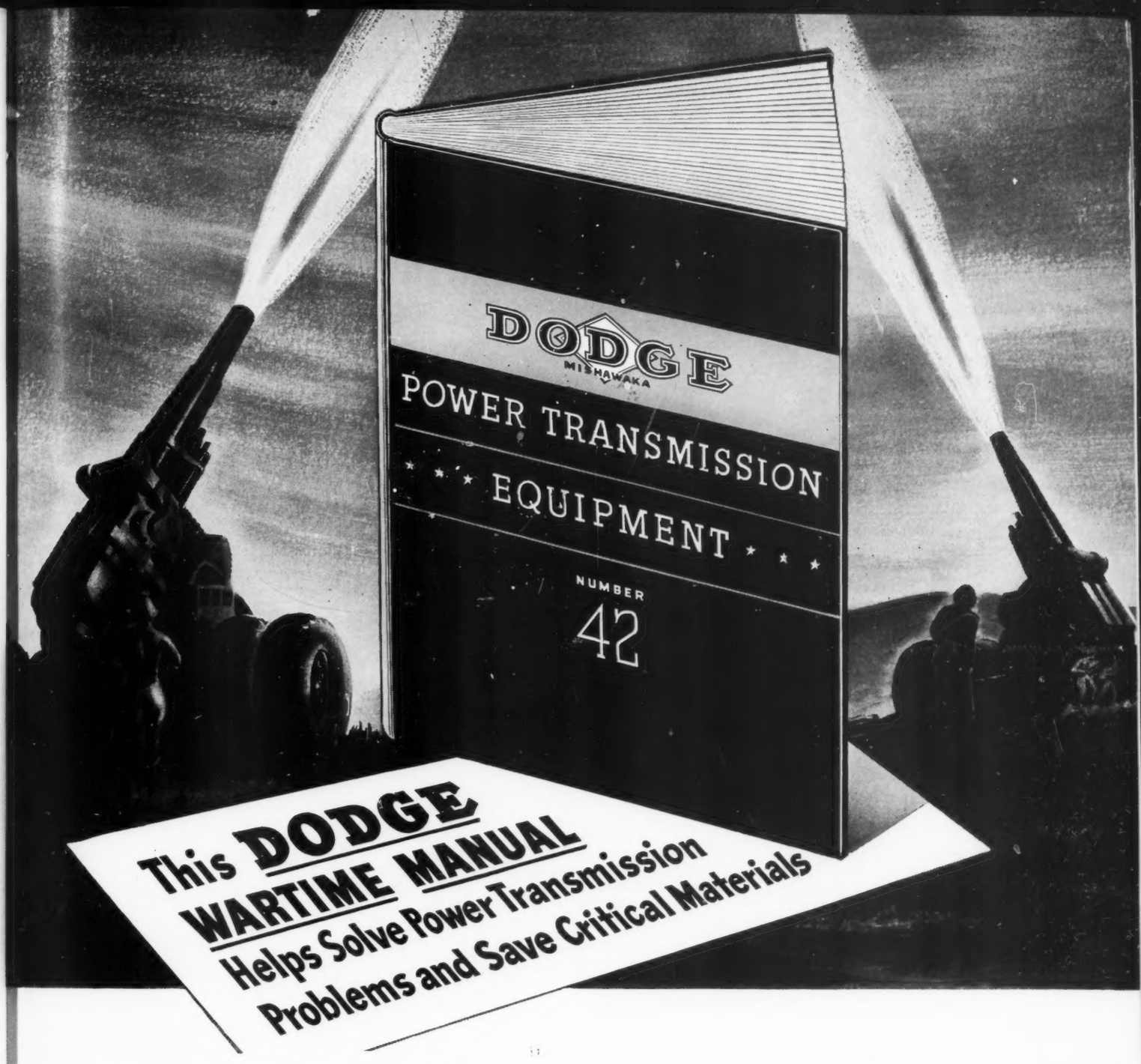
FOR MEN WHO NEED TO KNOW
ABOUT PLASTICS DESIGN



Here—in a new 16-page bulletin—are the latest facts about designing molded plastics parts. This information has been prepared by General Electric Engineers who form the expert engineering staff of One Plastics Avenue, where stands the largest plastics molding plant in this country. Product engineers to whom we have shown this new bulletin declare that it is indispensable for men working with plastics. For copies write Section D-1, Plastics Department, General Electric Company, One Plastics Avenue, Pittsfield, Mass.

PLASTICS DEPARTMENT
GENERAL ELECTRIC

PD-21



This DODGE WARTIME MANUAL Helps Solve Power Transmission Problems and Save Critical Materials

THIS Dodge Wartime Manual of Mechanical Power Transmission has been compiled to assist in solving wartime power problems — to conserve power, increase production and save critical materials.

It is being released at a time when conservation of motors, power and critical materials is of vital importance. It is the "How Book" of the Dodge program aimed at helping industry to increase production — built around the fighting slogan — *"put all your power in the job."*

The new Dodge catalog offers alternate power transmission appliances that save critical metals — and help to throw more scrap into the fight. It presents power transmission equipment that steps up production — saves time —modernizes and increases productivity of present equipment — quickly — economically — effectively.

Between the covers of this new catalog, you will find "The Right Drive for Every Job" — Dodge D-V drives — bearings — pulleys — clutches and other power transmission appliances designed for use on individual, multi-motor and modern group drives.

Modern planned mechanical power transmission is a potent weapon ready *now* to wage war on power and material waste — to get more battle power out of horsepower.

Write today on your firm letterhead for the Dodge Wartime Manual of Mechanical Power Transmission.

DODGE MANUFACTURING CORPORATION
Mishawaka, Indiana, U. S. A.

THROW ALL YOUR SCRAP INTO THE FIGHT!

BUY U. S. WAR BONDS FOR VICTORY

DODGE
MISHAWAKA

THE RIGHT DRIVE FOR EVERY JOB

GEARED FOR LONGER LIFE...

By Flame Hardening

In only 8 seconds the wear resistance of this internal gear is increased — its service life extended, by flame hardening. This process quickly hardens wearing surfaces without affecting the toughness or shock resistance of the core metal.

Flame hardening offers all the benefits of other surface hardening methods and in addition provides speed, flexibility, simplicity and economy. Moreover flame hardening permits treating surfaces which cannot otherwise be handled due to size or shape. Since it is performed on finished surfaces, machining and regrinding operations are considerably reduced.

The services of Air Reduction's engineering and research consultants are available for practical assistance on your individual problems. We will be glad to supply detailed information and technical advice on the flame hardening process. Write your nearest Airco office for details.

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General Offices: **60 EAST 42nd ST., NEW YORK, N. Y.**

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PROUDLY

our men and women wear their emblems of honor

We are privileged to serve the war effort directly—in the making of important fire-control instruments... Our men and women won their first "E" Award in August 1941—their second in May 1942. It is now our privilege to fly our third flag—the Army-Navy Production Award pennant with two stars affixed. ★ ★ The regular K&E line is also in the service. Mechanical and civil engineers and draftsmen—engaged in war work—make daily use of K&E slide rules, drawing instruments, surveying instruments, drafting machines, tracing papers and tracing cloths.

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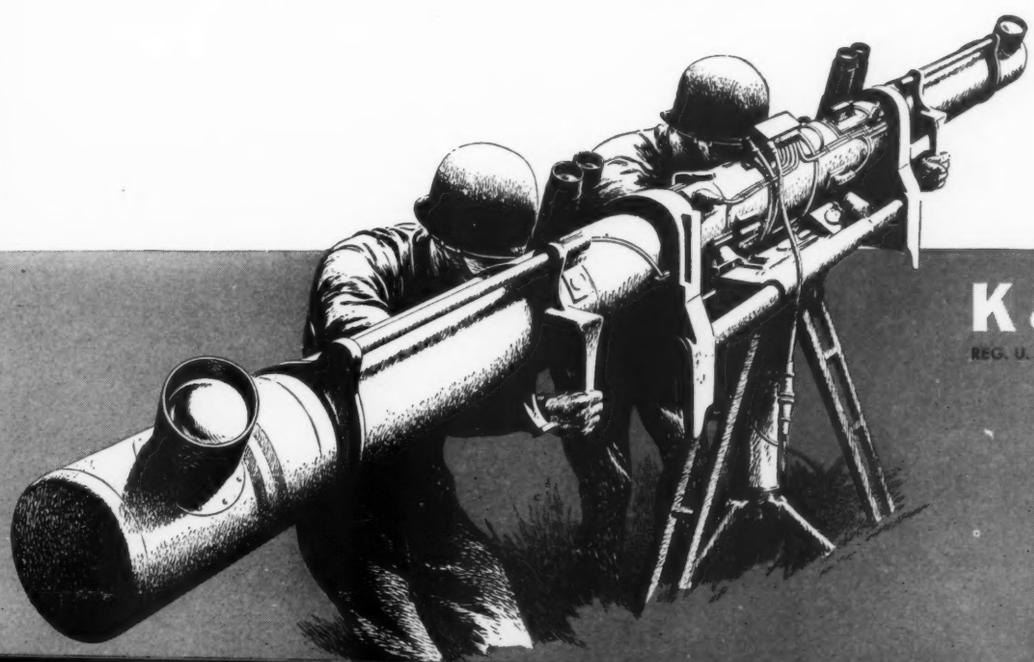

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REG. U. S. PAT. OFF.

"Know How" to do it Better - Faster... with

"LOGAN" AIR and HYDRAULIC EQUIPMENT

Designed to save time, effort and motion, "LOGAN" Air and Hydraulic Equipment has solved production problems and speeded up manufacturing in the leading industrial plants of the world. Easily adaptable to all types of production machines, thousands of uses have been found to do the job "better and faster" with "LOGAN" Equipment. The line is complete and includes Air and Hydraulic Control Valves, Rotating and Non-Rotating types of Air and Hydraulic Cylinders, Air and Hydraulically Operated Chucks, Hydraulic Power Units, Relief and Reducing Valves, Presses, Vises, "Sure Flow" Coolant Pumps, etc. "LOGAN" Engineers will be glad to make recommendations on your requirements — or write for any of the catalogs or bulletins shown.

LOGANSPORT MACHINE, Incorporated

912 Payson Road Logansport, Ind.

Wartime ceramics

Mugs, jugs and goblets were about the only ceramics actively participating in past wars. Spirits were enlivened and convictions reaffirmed by mugs and plates bearing appropriate sentiments. Gay commemorative jugs, fashioned by earlier American ceramists, helped perpetuate the memory of men famed in war and peace.

But today ceramics play an active and vital role in war. Complex electrical mechanisms depend upon ALSIMAG steatite ceramic insulation for unfailing performance.

It was a proud day for American Lava Corporation when it was the first in the land to produce electrical insulators meeting Navy "G" specifications. Since that time ALSIMAG insulators complying with the toughest specifications of Army and Navy have gone out of this plant in an ever-increasing flood.

The men who make ALSIMAG have only one regret. The all-out efforts of the past two years have forced them to lose touch, for the time being, with many peacetime friends and customers. Every consideration beyond the war effort was proudly and gladly thrust aside. But when peace comes, you will find that the stresses and strains of war have resulted in new and better ALSIMAG products, backed by the same alert organization ready to serve you in the same old spirit of friendly helpfulness.

ARMY E NAVY

AWARDED JULY 27, 1942

ALSIMAG

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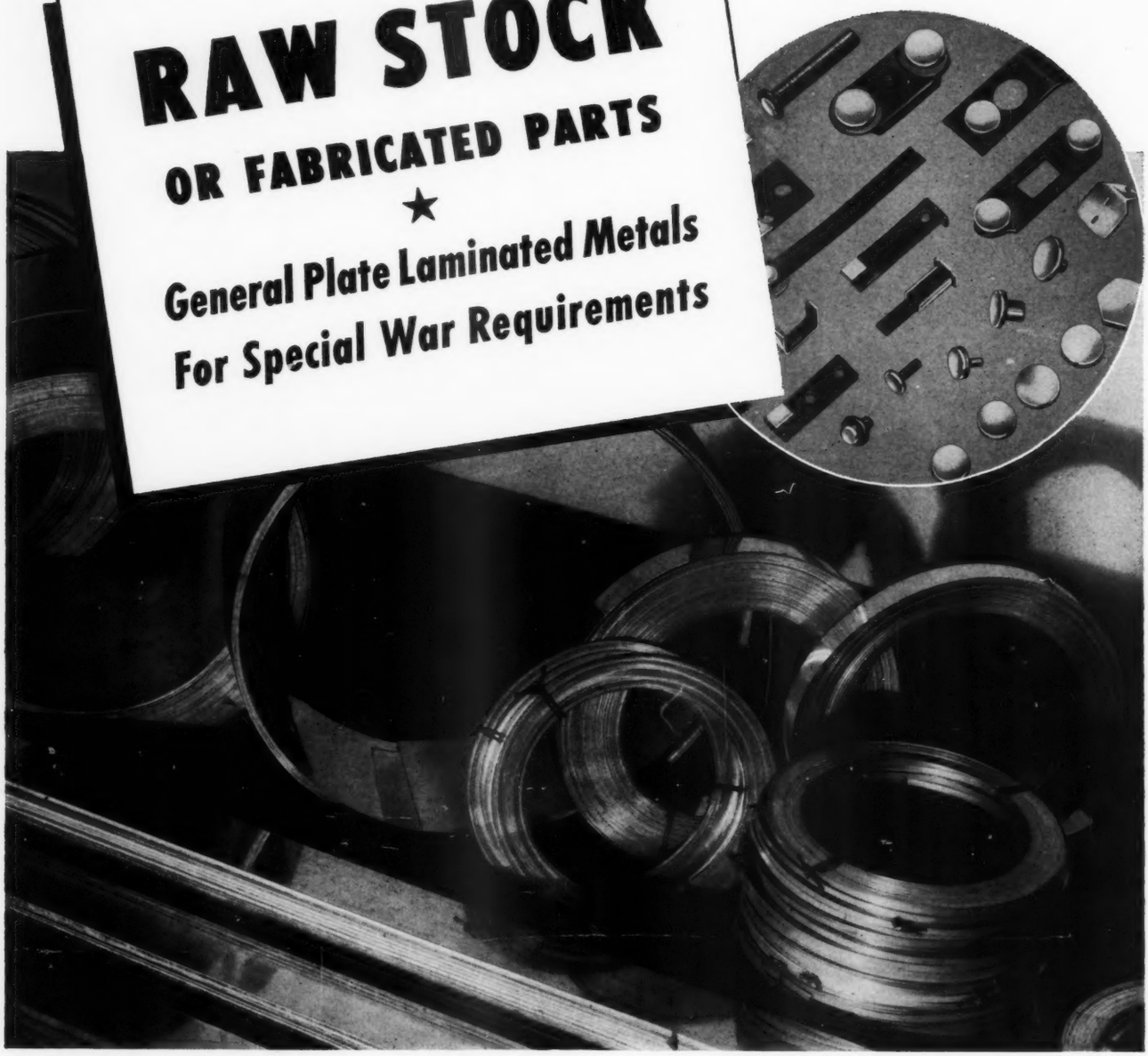
AMERICAN LAVA CORPORATION

CHATTANOOGA, TENNESSEE

RAW STOCK
OR FABRICATED PARTS
★
General Plate Laminated Metals For Special War Requirements



If you have metal problems that concern production of war products, let General Plate Engineers help you out. From our large assortment of laminated metals—permanently bonded combinations of metals—you can get metals that will take care of many of the special requirements of the chemical, electrical, aircraft and radio industries—metals for more effective corrosion resistance, or better contact performance, or substitutes for scarce materials.

General Plate Laminated Metals are available in flat stock, strips, coils, wire and tubing, or in special parts fabricated to your designs. Write, specifying your problems, and our engineers will gladly offer their recommendations.

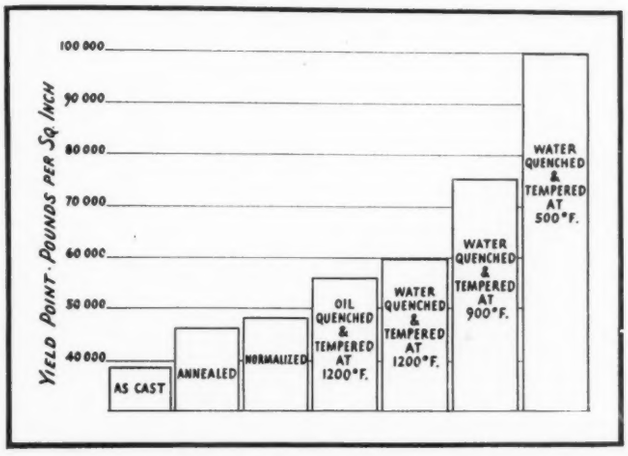
General Plate Division

of Metals & Controls Corporation

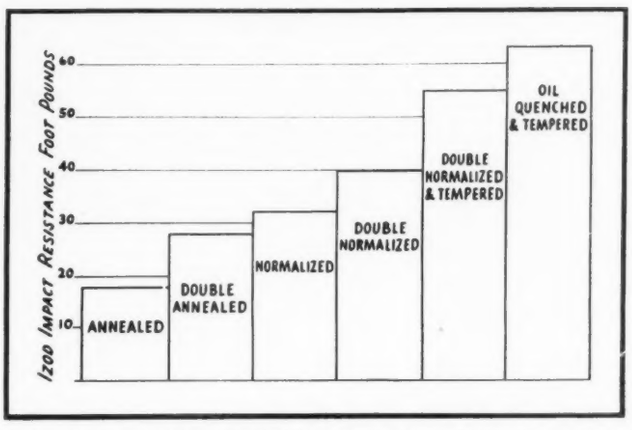
Metals and Controls Corporation Divisions manufacture the following products: Laminated & solid precious metals, electrical contacts—Solid and rolled plated precious metals in all forms—Truflex Thermostatic Bimetals.

ATTLEBORO, MASSACHUSETTS

SPECIFY THE MATERIAL THAT FULFILLS ALL OF YOUR REQUIREMENTS ...NO MATTER HOW SEVERE THE CONDITIONS



Showing how the Yield Point of carbon cast steel may be increased by heat-treating.



Showing how Impact Resistance of an alloy cast steel may be increased by heat-treating.

Cast steel is a versatile material.

If you must have great strength and toughness, or extreme rigidity, or extra hardness, or resistance to wear, temperature, stresses, or fatigue, you can write your own ticket.

Cast alloy steels are produced with all of these characteristics, in any combination, and their desirable mechanical properties are readily enhanced by heat-treating.

Special alloys may be specified in limited quantities without the delay or extra cost of small mill runs—an important factor in war production.

Complicated shapes may be had in close to final form, yielding big savings in machining, finishing and assembly.

The charts on the left indicate the wide range of properties that may be obtained by heat-treating typical commercial cast steels.

This new booklet gives information on the mechanical properties of cast steel compared with other cast ferrous metals.

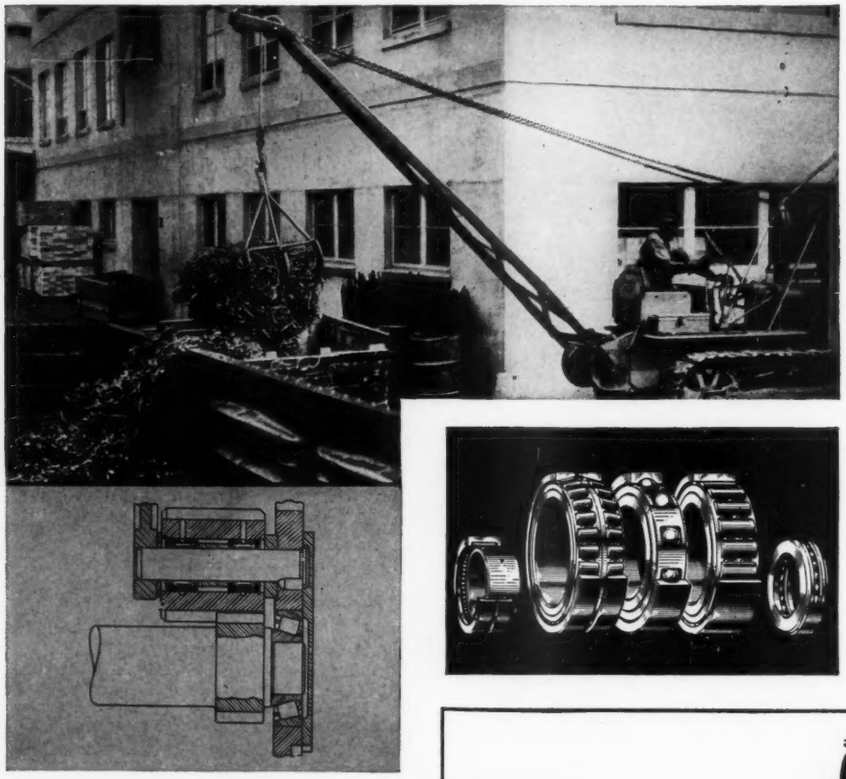
Address the Steel Founders' Society, 920 Midland Bldg., Cleveland, Ohio. Enclose 10c postage.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

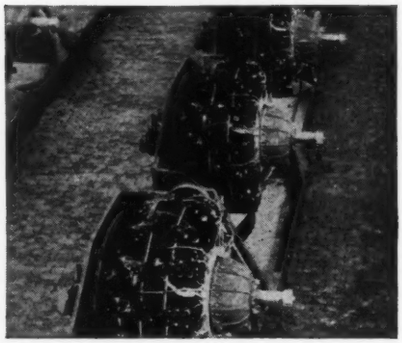
IN THE NEWS
WITH BANTAM BEARINGS

70 TONS OF FLYING BOAT, the Mars provides a new cargo carrier of tremendous speed, and offers a forecast of the aerial transportation of the future. Built for the Navy by The Glenn L. Martin Company, the Mars, with its 200-foot wing spread and its four 2000-HP motors, requires a giant beaching gear to maneuver it on land. And in the gear the entire load is carried on large-size Bantam Ball Thrust Bearings made of stainless steel to resist attack by salt air and water—another instance of Bantam's skill in supplying bearings for radically new requirements.



FROM TOWING WINCH TO CRANE by the addition of a boom is the transformation undergone by this versatile Willamette Hyster winch, now handling scrap in a metal refining plant. Winches of this type use Bantam Quill Bearings on reverse idler pinion (as shown in cross-section drawing) and in idler gear.

THE GENERAL GRANTS CAN TAKE IT, as these 30-ton tanks conclusively demonstrated in the Egyptian campaign. And in the tank transmissions, Quill Bearings are again proving their ability to perform efficiently and reliably under the most severe service conditions. For further information on this compact, high-capacity anti-friction bearing, write for Bulletin R-104.



BANTAM NEEDLE ROLLERS are assembled into anti-friction units of exceptionally high load capacity, low cost, and small size, for use in many of America's foremost aircraft engines. Where anti-friction is a *must*, and size, weight, and installation are factors in design, Bantam Needle Rollers fill many important jobs.

←IF YOU NEED ANTI-FRICTION BEARINGS for war applications or tomorrow's designs, you will probably find what you want among Bantam's comprehensive line, which includes straight roller, tapered roller, needle, and ball. Or if you need *special* bearings, Bantam engineers will design them. For help on your bearing problems, TURN TO BANTAM.

ETHOCEL SHEETING
-flexible at 70 below!

Flexibility at temperature extremes is an essential quality in nearly all plastic sheeting applications. For, without flexibility *under widely varying conditions*, your product may fail when it is needed most urgently.

On this point alone, ETHOCEL* Sheeting merits your thorough investigation. Tests show that it remains flexible at temperatures as low as —70° F. Even when it arrives at your plant in subzero weather, no preconditioning is necessary before fabrication.

ETHOCEL Sheeting (made of Dow ethylcellulose, the toughest cellulose material commercially available) also retains its inherent qualities of flexibility and toughness at temperatures as high as 200° F. As a result, it can be specified for use where weather conditions are extremely divergent. Consider this fact now—then plan your new product.

SCORING AND BEADING WITHOUT BREAKING

ETHOCEL Sheeting does not depend upon plasticizers to take scoring and folding without breaking or tearing. Moreover, it can be scored and folded *through a beaded edge*. This makes beading practical for rectangular boxes as well as cylindrical shapes —giving both increased rigidity.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • St. Louis • Chicago • Houston • San Francisco • Los Angeles • Seattle

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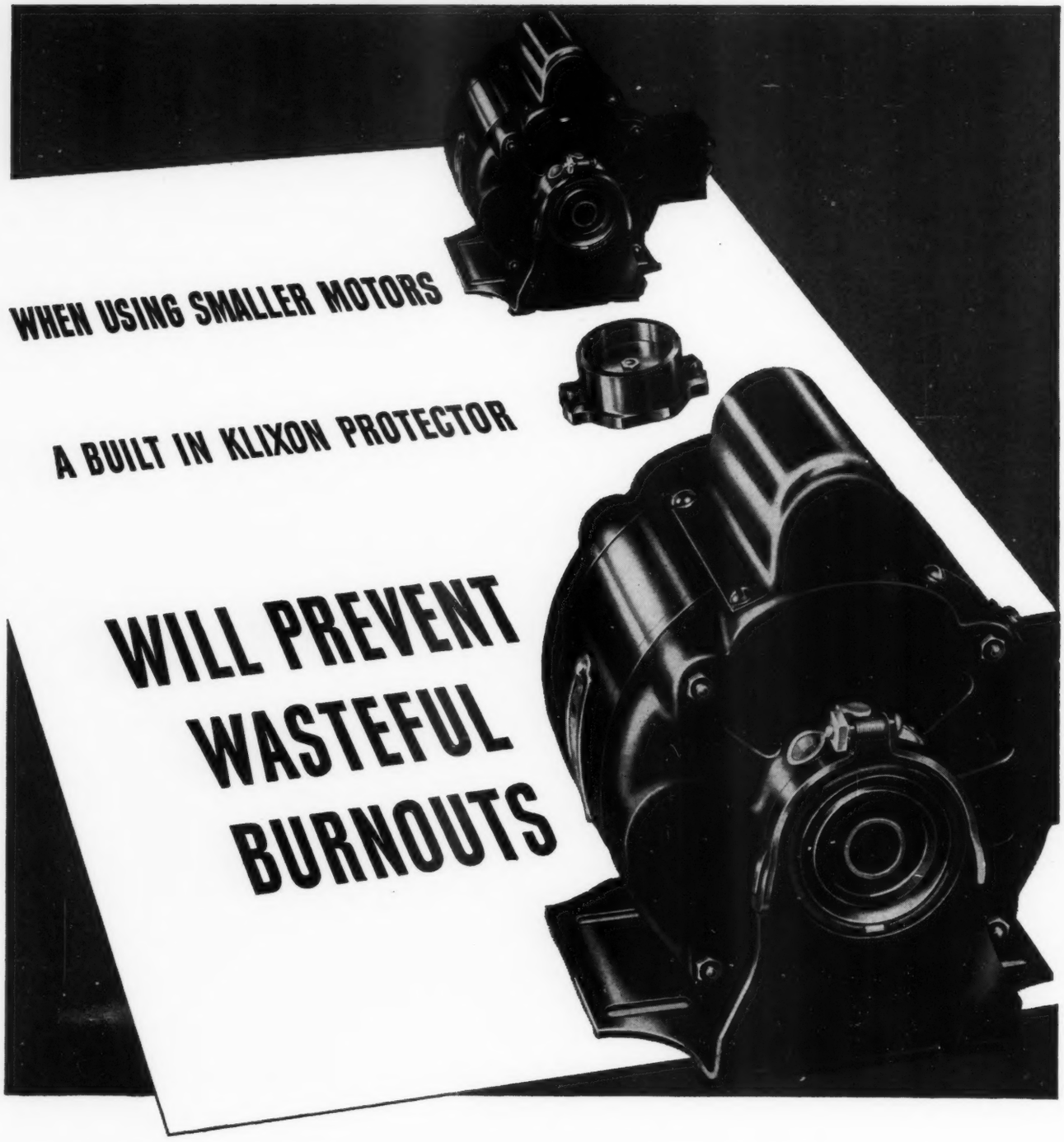
PLASTICS

STYRON SARAN ETHOCEL

DOW

CHEMICALS INDISPENSABLE TO INDUSTRY AND VICTORY



A motor with a built-in Klixon Protector is 100% efficient and 100% safe. It needs no safety allowance. You can run it continuously right up to peak capacity without any danger of burnouts from overloading. The instant the motor gets dangerously hot, the Klixon Protector automatically shuts off the motor until it cools to a safe operating temperature—at which time the motor starts again either automatically or by manual reset.

Now—when the government recommends the use of smaller motors in order to save vital materials—it is doubly important to insist on built-in Klixon Protectors. Any motor—A.C. all sizes of D.C. up to 30 volts —can be supplied with a built-in Klixon Protector.

KLIXON

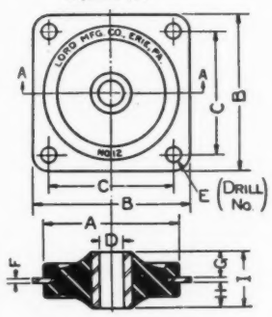
SPENCER THERMOSTAT COMPANY, ATTLEBORO, MASSACHUSETTS, U.S.A.

Designing . . .

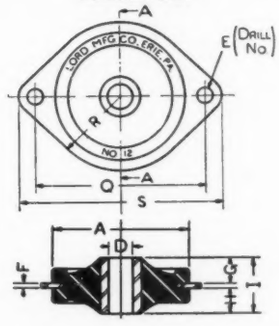
FOR USE OF LORD BONDED RUBBER MOUNTINGS

SPECIFICATIONS FOR
LORD STANDARD PLATE FORM MOUNTINGS

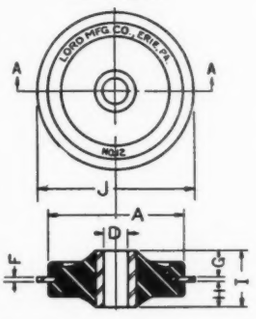
Square (P)



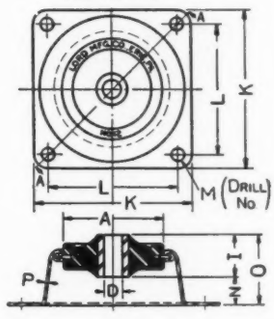
Diamond (PD)



Round (PR)



Holder (PH)



A study of the dimensional charts and illustrations will show that designing for use of Lord Plate Form Mountings in any equipment does not involve intricate layouts. Neither special tooling nor precision machining is necessary to accommodate them. Simply provide clearance for rubber body of mounting, bolts or screws for attaching plates, and bolt or stud for attaching the equipment to center sleeve. Lord Plate Form Mountings can be used in either a supporting or suspension position with equal effectiveness.

Lord Mountings are made in Plate Form and Tube Form, in snubbing and non-snubbing types and with load ratings ranging from a few ounces up to 1500 pounds. The principle of stressing rubber in shear when load is imposed, is used in all Lord Mountings.

Properly installed, all Lord Mountings definitely: Prolong equipment life by isolating vibration, which reduces metal fatigue, and prevents mechanical failure; increase production through elimination of close machining and precision alignment; save vital material by reducing equipment weight—inertia masses of machinery bases can be decreased in weight or eliminated; increase personnel efficiency by eliminating nerve wearing noise and vibration, translated through solid conduction; lower maintenance costs by protecting equipment against sudden load shocks and stresses, thereby minimizing repair and replacement operation.

For complete information covering all Lord Mountings, as well as an engineering discussion on vibration control, write for Bulletins 103 and 104, or call in a Lord Vibration Engineer for consultation on your design problems. There is no obligation.

Series	A	B	C	D	E	F	G	H	I
100	1″	1¼″	1″	.166″	.141″	.032″	.203″	.172″	13/32″
150	1½″	1¾″	1⅜″	.257″	.166″	.050″	.287″	.287″	5/8″
200	2″	2¼″	1¾″	.391″	.196″	.058″	.471″	.471″	1″
200X	2″	2¼″	1¾″	.391″	.196″	.058″	1.283″	.471″	1 13/16″

Series	J	K	L	M	N	O	P	Q	R	S
100	1 3/16″	1 11/16″	1⅜″	.141″	5/16″	23/32″	.025″	1.414″	5/8″	1.664″
150	1¾″	2⅜″	1 15/16″	.196″	7/16″	1 1/16″	.032″	1.945″	⅞″	2.320″
200	2¼″	3″	2½″	.257″	½″	1½″	.037″	2.475″	1⅛″	2.975″
200X	2¼″	3″	2½″	.257″	½″	2 5/16″	.037″	2.475″	1⅛″	2.975″

Series	Normal Load Rating 1/16″ Deflection	Maximum Allowable Load
100	1 to 4 lbs.	1 to 4 lbs.
150	2 to 12 lbs.	3 to 18 lbs.
200	10 to 45 lbs.	20 to 90 lbs.
200X	60 to 90 lbs.	120 lbs.

These specifications on Lord Shear Type Bonded Rubber Mountings cover *Standard* Plate Form Types only. Cross sectional drawings show mountings under *rated load.* As shipped, dimension "G" is 1/16″ larger and dimension "H" is consequently 1/16″ smaller. On Holder Type, dimensions "N" and "O" will be 1/16″ larger. Data on all other Lord Mountings is contained in our engineering bulletins. For special shapes, load ratings, materials or finishes, apply to factory

ORIGINATORS OF SHEAR TYPE BONDED RUBBER MOUNTINGS

LORD MANUFACTURING COMPANY . . . ERIE, PA.

SALES REPRESENTATIVES . . . NEW YORK, 280 Madison Ave. . . . CHICAGO, 520 N. Michigan Ave. . . . BURBANK, CAL., 245 E. Olive Ave.

GRAPHITAR

has solved a host of material problems · · · how about yours?

● Confronted with a materials problem could you use a product that is—

- **mechanically strong**
- **heat resistant**
- **chemically inert**
- **Self-lubricating**
- **easily machined to close tolerances**
- **low in density**
- **will not shrink or expand**

If so, then it will pay you to investigate GRAPHITAR and consult with United States Graphite Engineers on your materials problems. GRAPHITAR is now being used by hundreds of companies in all manner of applications. A few of these are small and large bearings —electrical contacts—solid carbon molds—steam turbine seal rings—pump and compressor blades and many others.

The booklet illustrated tells all about GRAPHITAR—what it is—where it comes from—and illustrates and describes a few of its many uses. Write for a copy today. In addition a staff of research and field engineers are available to help you on your materials problems. Consult them.

THE UNITED STATES GRAPHITE CO.

SAGINAW, MICHIGAN
U. S. A.

The United States Graphite Company, Saginaw, Michigan, U. S. A.

Please send me your booklet "GRAPHITAR"

NAME ..... TITLE .....

COMPANY .....

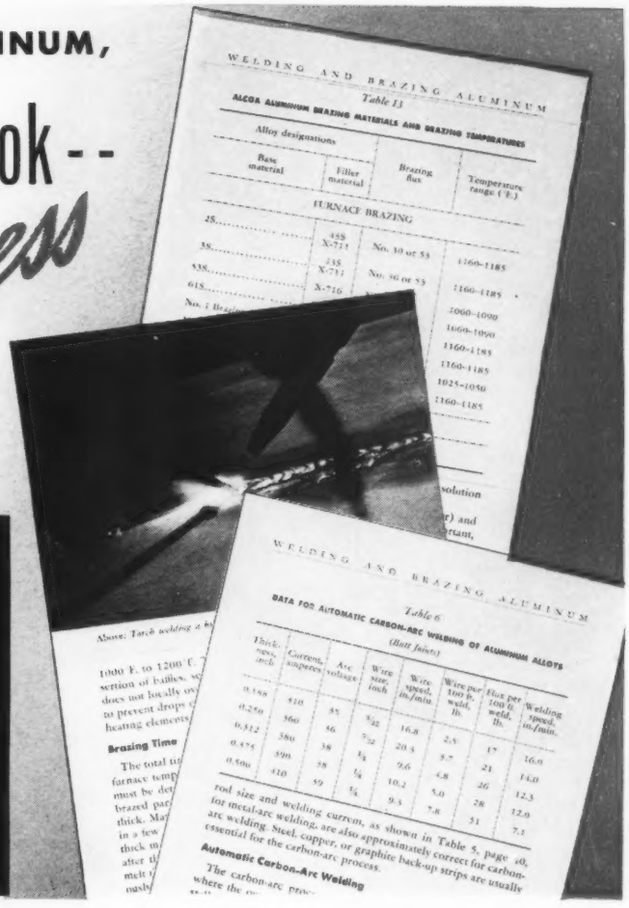
STREET .....

CITY ..... STATE .....

IF YOU'RE WORKING WITH ALUMINUM,

you should have this book--

just off the press



WELDING AND BRAZING ALCOA ALUMINUM

Here's a book of data designed to meet the needs of the practical man—the welder—who is working with Aluminum Alloys. It describes in detail the practices now widely employed for joining Aluminum parts by gas welding, arc and resistance welding, and by brazing.

This book is planned to assist the war effort by making every welder more proficient at his job. Typical subjects covered are: Welded joint design—preparation of parts—types of welding equipment—electrodes and fluxes—tip selection and flame adjustment—inspection and finishing—strengths of welds.

Joining Aluminum Alloy parts by welding and brazing is readily mastered with knowledge like this at your command, plus a little practice. You may have this book free. Use the coupon to send for your copy today.

ALCOA

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA,
2193 Gulf Bldg., Pittsburgh, Pa.
Please send me this new book.

Name_____

Company_____

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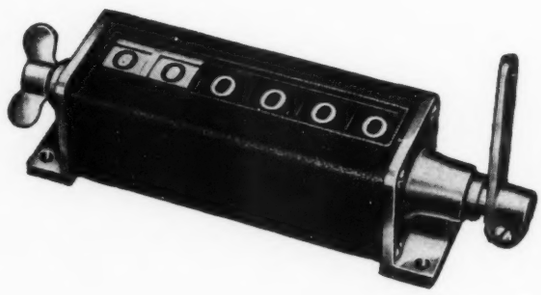
What your machines could do with built-in Bull Fighters!

It's easy to fit the war-production machines you build with Veeder-Root Counting Devices that will help your customers to fight off the "bulls" . . . from miscounts and guesswork . . . that charge in and rip up production schedules where no up-to-the-minute operating records are available. With Veeder-Root facts in figures, they will be helped to avoid shortages and over-runs . . . to see maintenance needs well in advance of danger-points . . . to control high speed runs . . . and to improve interdepartmental co-ordination toward final assembly.

In sum, these truth-telling devices will help your customers to get, *consistently*, top performance out of your equipment. They are compact enough to fit readily into your designs . . . and can be supplied to count in any terms or units, mechanically or electrically. So if you are building war-production machines, fit them to make their work count to the utmost . . . with built-in Veeder-Root Devices.

VEEDER-ROOT Reset Stroke Counter with Totalizing Unit (the black-on-white figures at the left). A Medium Size Counter for speeds up to 1,000 counts per minute.



Veeder-Root Inc.

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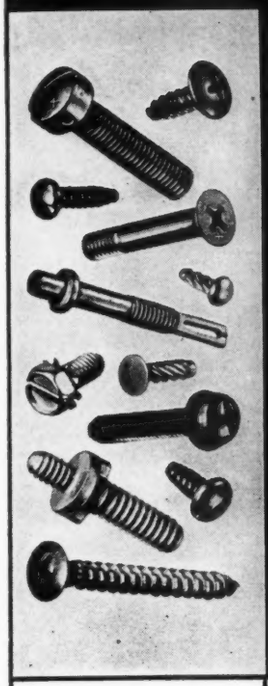


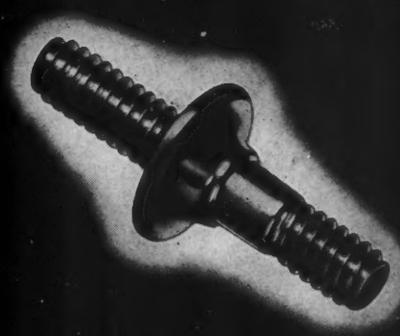


Illustration 1½ times actual size

"Know how" proof #5
...more each month

SOME SCOVILL STANDARD SCREW PRODUCTS

- AN HEX. HEAD AIRCRAFT BOLTS
- AN AIRCRAFT SCREWS
- AN ALLOY STEEL AIRCRAFT SCREWS
- PHILLIPS RECESSED HEAD SCREWS
- PHILLIPS RECESSED AIRCRAFT SCREWS
- STANDARD BRASS AND STEEL MACHINE SCREWS
- SHEET METAL SCREWS TYPE A & Z
- SELF-TAPPING SCREWS TYPE F
- WASHER ASSEMBLED SCREWS
- SPECIAL HEADED AND THREADED FASTENINGS

Here at Scovill we know how to figure out and produce in quantity the kind of special and standard fastenings that can be trusted to do a job on the Job. And we can *prove* our "know how" to you by tough problems promptly solved.

That brass special fastening above—one of our many war jobs—is a good case in point. A heading and a cold forging operation, plus secondary drilling and threading, turned the trick. And we can fill your needs to your full satisfaction with the same minimum of metal, money and motions.

This "know how" of ours is important to you because your products will be no better than their fastenings, and your problems no simpler than your ability to find expert help. Whether your problem is immediate production or Post-War planning, it will pay you to get in touch with the nearest Scovill fastenings expert listed below. You'll get fast action to the absolute limits that our war-vital commitments permit.

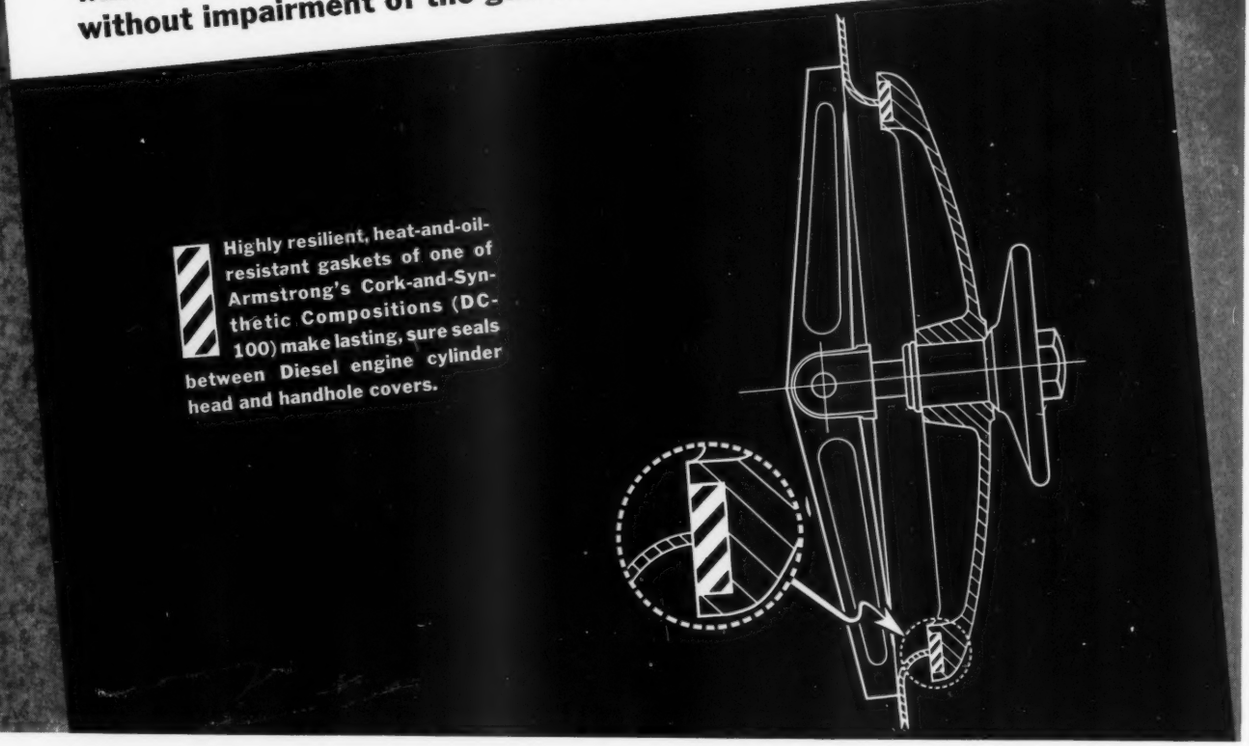
SCOVILL MANUFACTURING COMPANY
WATERVILLE SCREW PRODUCTS DIVISION

WATERVILLE, CONN. TEL. WATERBURY 3-3151

NEW YORK, Chrysler Bldg. • DETROIT, 6432 Cass Ave. • CHICAGO, 1229 W. Washington Blvd. • PHILADELPHIA, 1617 Pennsylvania Blvd.
PITTSBURGH, 2882 W. Liberty Ave. • SYRACUSE, Syracuse-Kemper Insurance Bldg. • LOS ANGELES, 2627 S. Soto St. • SAN FRANCISCO, 434 Brannan St.

CASE HISTORY No. 207 FROM OUR GASKETS FILE

PROBLEM: To find a Diesel engine handhole cover gasket which would permit frequent removal and replacement of the cover without impairment of the gasket's sealing efficiency.



Highly resilient, heat-and-oil-resistant gaskets of one of Armstrong's Cork-and-Synthetic Compositions (DC-100) make lasting, sure seals between Diesel engine cylinder head and handhole covers.

A MANUFACTURER of Diesel engines needed better handhole cover gaskets. The ones he'd been using sealed efficiently enough, but would usually stick and often break when the handhole covers were removed. Inasmuch as the covers are removed and replaced frequently, this disadvantage was a real nuisance.

The gasket material desired was one which would (1) tightly seal lubricating oil inside the engines; (2) resist the deteriorating effects of the oil; (3) withstand the relatively high operating temperatures of the engines; (4) retain its sealing efficiency despite frequent removal and replacement of the covers.

Solution

When this problem was presented to Armstrong's sealing specialists, they suggested one of Armstrong's Cork-and-Synthetic Compositions, DC-100. The cork in this composition assures true compressibility with permanent resilience for sure sealing. The composition has the necessary resistance to oil and successfully withstands the engine heat. DC-100 was adopted for sealing the engine handholes and has been giving satisfactory service ever since.

Rolls, Sheets, Gaskets, Molded Parts

The solution to *your* sealing problem may likewise be found among the more than fifty efficient sealing materials Armstrong makes. These include cork, synthetic, cork-and-synthetic, and cork-and-rubber compositions; No. 841 Fibrated Leather; and rag felts. Armstrong's Compositions having virtually any desired physical properties are available in rolls and sheets, in molded shapes, cut gaskets, and extruded rings. Write today for your free copy of the booklet describing Armstrong's Gaskets, Packings, and Seals. Armstrong Cork Company, Industrial Division, 7101 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S
GASKETS · SEALS
PACKINGS

Rubber-like Synthetics
*Cork-and-Synthetics • Cork-and-Rubber
Cork Compositions • Fibrated Leather

*FORMERLY "CORPRENE"

This cord tip body is molded in two halves, each .385″ long and .053″ thick, with minimum tolerances checked at 63 points—9,088 pieces produced to the pound. Note the two holes in one half—diameters .045″ ± .001″ and .062″ ± .001″. Quite a molding feat!

. . . No Plastic Part Seems Too Intricate for Custom Molders

WITH a thickness of just over 1/20″ to each half—no finishing necessary—this cord tip body is a precision part that shows how custom molders can work in almost infinitesimal dimensions and close tolerances.

They are equally at home molding large parts measured in feet and weighing over a pound.

The range of parts that custom molders are turning out today from plastics—by injection, compression, transfer or extrusion—is proving of tremendous help to manufacturers in the war emergency. If you need a part or a complete product, chances are it can be molded from plastics.

Here's how to find out:

1. *Tell us what qualities you want in the part—impact strength; resistance to solvents, acids, water; light transmission; dielectric strength, etc. We select the plastic to give desired results.*

2. *We put you in touch with the available custom molders equipped to mold the piece.*

3. *The custom molder gives you a quotation.*

4. *We work with the custom molder in furnishing the formulation of the selected Lumarith Plastic that suits all factors of the production technique.*

Inquiries invited.

LUMARITH *Plastics*
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Lumarith Molding Powders (Cellulose Acetate)
Lumarith E. C. Molding Powders (Ethyl Cellulose)

CELANESE CELLULOID CORPORATION, *a division of Celanese Corporation of America*, 180 Madison Avenue, New York City. *Representatives:* Dayton, Chicago, St. Louis, Detroit, San Francisco, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto, Ottawa.

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the first name in plastics

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Day and night, pausing only for changes, repairs or maintenance, countless thousands of machine tools — "Soldiers of Steel" in the army of production — are turning out armament, equipment and supplies, that Victory may be hastened. For them, there is no rest, no relaxing of effort. They must "keep on the job".
In thousands of these tools, built by practically every representative machine tool manufacturer, NORMA-HOFFMANN PRECISION BEARINGS are "standing the gaff" of this continuous service—and contributing accuracy, rigidity, speedability and dependability under the most gruelling conditions ever imposed upon machines.
The counsel of our engineers, with 30-odd years of experience in bearing application and maintenance, is yours on request—without obligation.
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PRECISION BEARINGS
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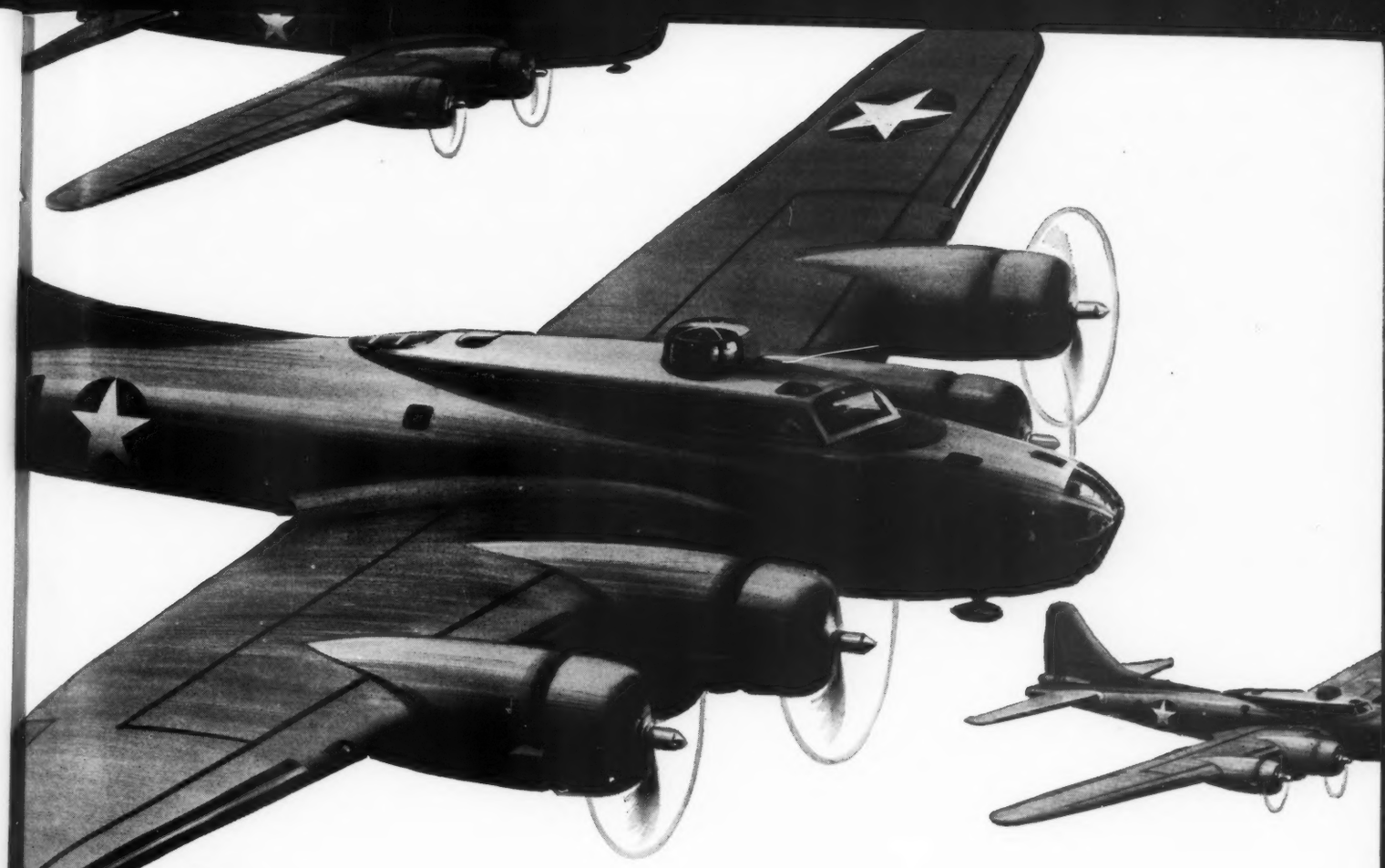
NORMA-HOFFMANN BEARINGS CORP'N., STAMFORD, CONN. . . . FOUNDED 1911



An Answer from the skies

"NO FOREIGN power can ever harm Germany from the air" was the boast of Hitler's air marshal. Yet today American planes, piloted by American airmen, are flying far into middle Europe, carrying loads of destruction to the mighty industrial plants—the huge utility system—the network of transportation lines that are all so vital to the Third Reich's military power.

This sky-borne answer to Goering's boast is dramatic proof of the quality of American planes—and the American engines that power them.

For as the size of these planes and the size of the loads they must carry have gone up—and up—and up—the engines that power them have kept pace. Today, motors of 2000 h.p. and over are an accepted fact with engineers looking forward to greater and greater horsepower in the motors of tomorrow.

What this increased horsepower means to the gears that transmit engine revolutions to the whirling propellers can well be imagined.

For aircraft gears must be light in weight, yet the slightest inaccuracy in gears revolving at such high speeds transmitting such great horsepower would quickly spell failure. No wonder aircraft engineers long considered such high precision gears a laboratory product.

But an air armada of the magnitude we are launching demanded that gears be produced by the hundreds of thousands.

That this problem was successfully solved is evidenced by the gears—thousands upon thousands of them—being daily turned out by the Precision Gear Plant of Foote Bros.—gears produced on a schedule that spells doom for the Axis ambition of world conquest.

And when the war is won, these new techniques and new methods that have made extreme precision in mass production possible promise a new era in the design of high speed machines for a peacetime America.

FOOTE BROS. GEAR AND MACHINE CORPORATION
5301 S. Western Boulevard • Chicago, Illinois

FOOTE BROS.

Better Power Transmission Through Better Gears

SABOTAGE ... *from the air*

Sharp . . . jagged . . . destructive! Not bombs. Merely little specks of dust . . . but far from harmless, as high-powered microscopes would show.

It is easy to imagine what damage these hard, jagged particles can do to precision finished bearing surfaces in equipment ranging from delicate instruments to heavy machines. When a highly finished part must be scrapped because of dust-damage, much more is lost than just a piece of metal. Many hours of expensive, painstaking labor are completely wasted.

One of the best defenses against dust-sabotage is air conditioning . . . the specially designed kind of air conditioning which, through efficient air filtering and accurate control of temperature and humidity, is making possible precision tolerances never before attainable.

General Electric has taken an outstanding part in the development of this new air conditioning. Already, the war has taught us how to make equipment more compact, more flexible, and far more efficient. Required "climates" are faithfully reproduced. When the war is over, air conditioning . . . better, cheaper, more universally used . . . will do much to make the world of the future happier and more useful for everyone. Then, as now—General Electric will be a leading source of all kinds of air conditioning.

Air Conditioning and Commercial Refrigeration Department, Division 431, General Electric Co., Bloomfield, N. J.

Air Conditioning by

GENERAL ELECTRIC

FIND METAL-CUTTING HORSEPOWER Quickly!

This newly developed load calculator makes it easy to figure the motor horsepower required for metal-cutting operations when the recommendations of the machine builder are unavailable. Its advantages? You can avoid *undermotoring* and save yourself production delays; you can avoid *overmotoring* and save the nation vitally needed steel, copper, and aluminum.

The G-E MOTORULE is accurate for a wide variety of cutting operations on lathes, drills, milling machines, and planers. It works on a wide range of materials, because you start from a convenient table of constants for the material being cut.

The results of many years of work by metal-cutting authorities were used by G-E engineers as a basis for the MOTORULE. The formulas were checked against actual load tests, and leading machine-tool builders were consulted.

The MOTORULE will help you in making sure of adequate motor capacity on machines being put to new war work, and in selecting motors for machines formerly driven from line shafting. To get your MOTORULE, just get in touch with your G-E Motor Representative. Or, if you wish, mail the coupon direct to General Electric, Schenectady, N. Y.

It's Easy with the G-E

MOTORULE*

First you refer to a convenient table of constants, printed on each rule, choosing the constant for the particular type of metal to be cut. Then by setting the scales to the known cutting speed, feed, and cut, you arrive at the cutting power required on the basis of ideal tool and machine conditions. Complete instructions are furnished with each MOTORULE.

*The MOTORULE is not intended to supplant the instructions of machine builders as to the power requirements of their machines. It is offered to fill the gap when these recommendations are unavailable.

SPECIFY TRI/CLAD MOTORS

REG. U.S. PAT. OFF.

Standard G-E Motors Are Generally Available without Delay for War Jobs

General Electric Co., Sec. J 750-159
Schenectady, N. Y.

☐ Please send your MOTOR FITNESS MANUAL, GED-1017.

☐ Please send me a G-E MOTORULE, with full instructions and leaflet giving the principles on which it is based.

Name.....

Title.....

Company.....

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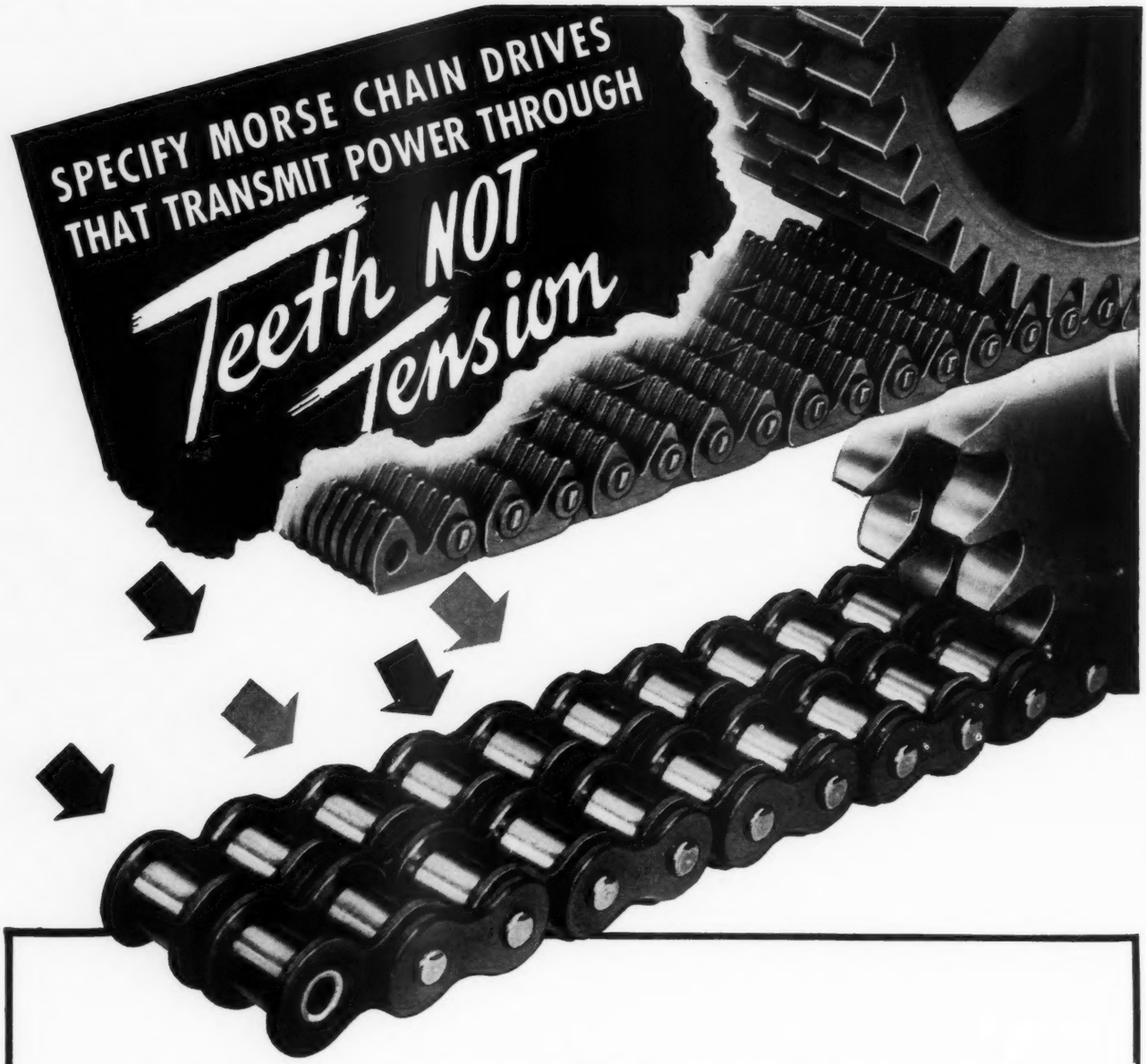
The Navy "E", for Excellence, has been awarded to 92,780 General Electric employees in six plants manufacturing naval equipment.

GENERAL ELECTRIC



POWER transmitted along slipping, inefficient drives rapidly becomes wasteful —causes undue expense and decreases machine capacity.

With the Morse Chain Drive principle—"Teeth Not Tension"—there is no chance for slip or power waste. All the power is turned into productive war action at practically 100% efficiency. Every Morse Drive is a completely engineered power transmission unit so selected and designed as to render unfailing service in the severest of conditions. There is no need for constant adjustment, inspection—Morse Drives operate for years requiring hardly any maintenance. To keep war production at maximum, specify Morse Chain Drives—your local Morse Drive Engineer will assist you.

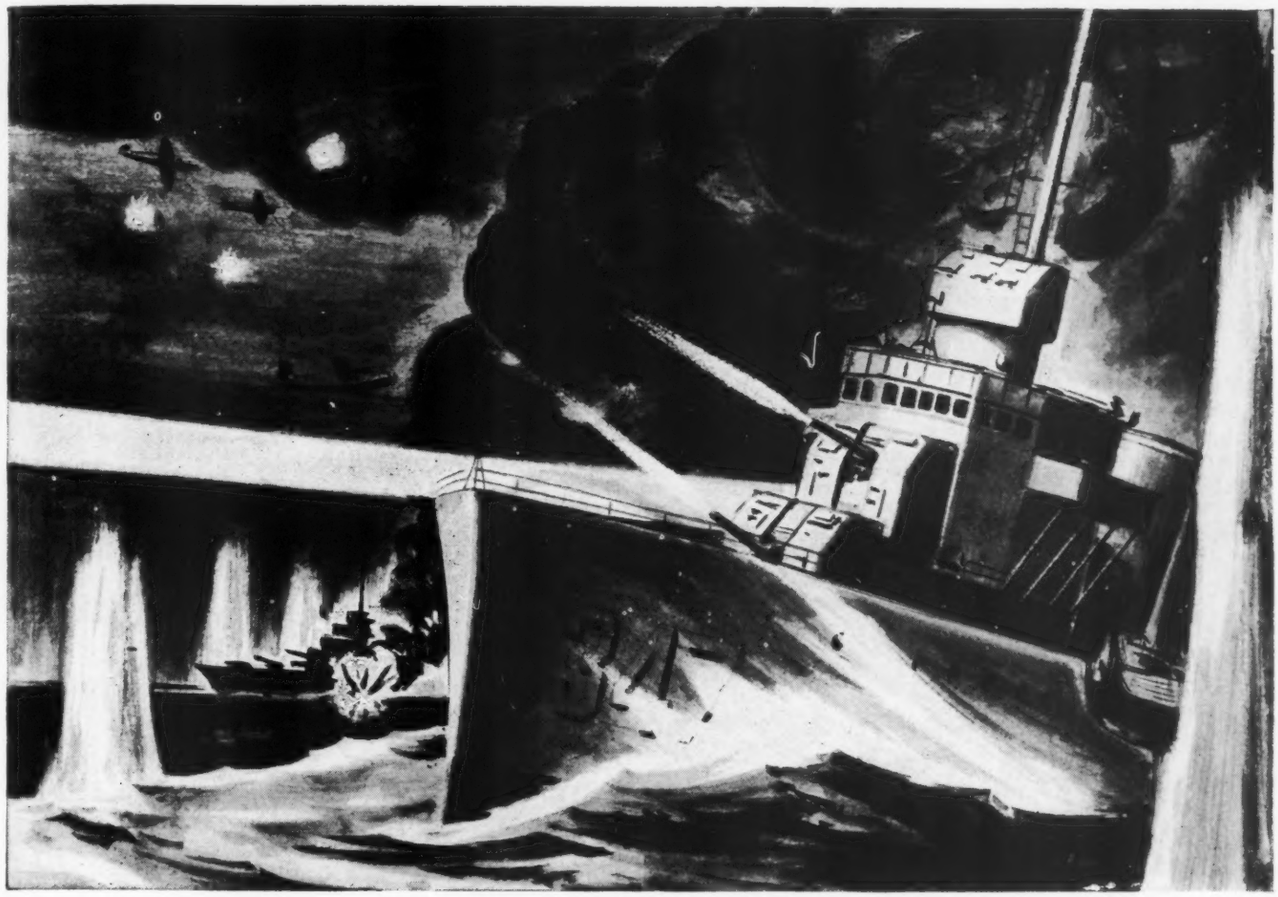
SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

VICTORY will be won

with alloy steel



and N-A-X *9100 Series*

SAVES VITAL ALLOYING ELEMENTS

Successfully used in hundreds of exacting peace-time products and parts, N-A-X 9100 Series of Alloy Steels aids war equipment production by conserving strategic alloying elements—without impairing quality.

N-A-X 9100 Series is being used as (1) a High Tensile Grade; (2) a Medium and Deep Hardening Carburizing Grade; (3) a Medium and Deep Hardening Constructional Grade. A truly remarkable achievement of Great Lakes engineers and metallurgists, the versatile N-A-X 9100 Series is readily adaptable in the manufacture of most armament appliances, either "as rolled" or heat treated.

Basically a low-alloy steel, with vital alloying elements held to an absolute minimum, N-A-X 9100 Series is supplied in two general grades—with and without molybdenum, all other components of the analysis being held constant. With deep hardening characteristics greater than or equal to the higher alloyed steels, no sacrifice of toughness or machinability is made.

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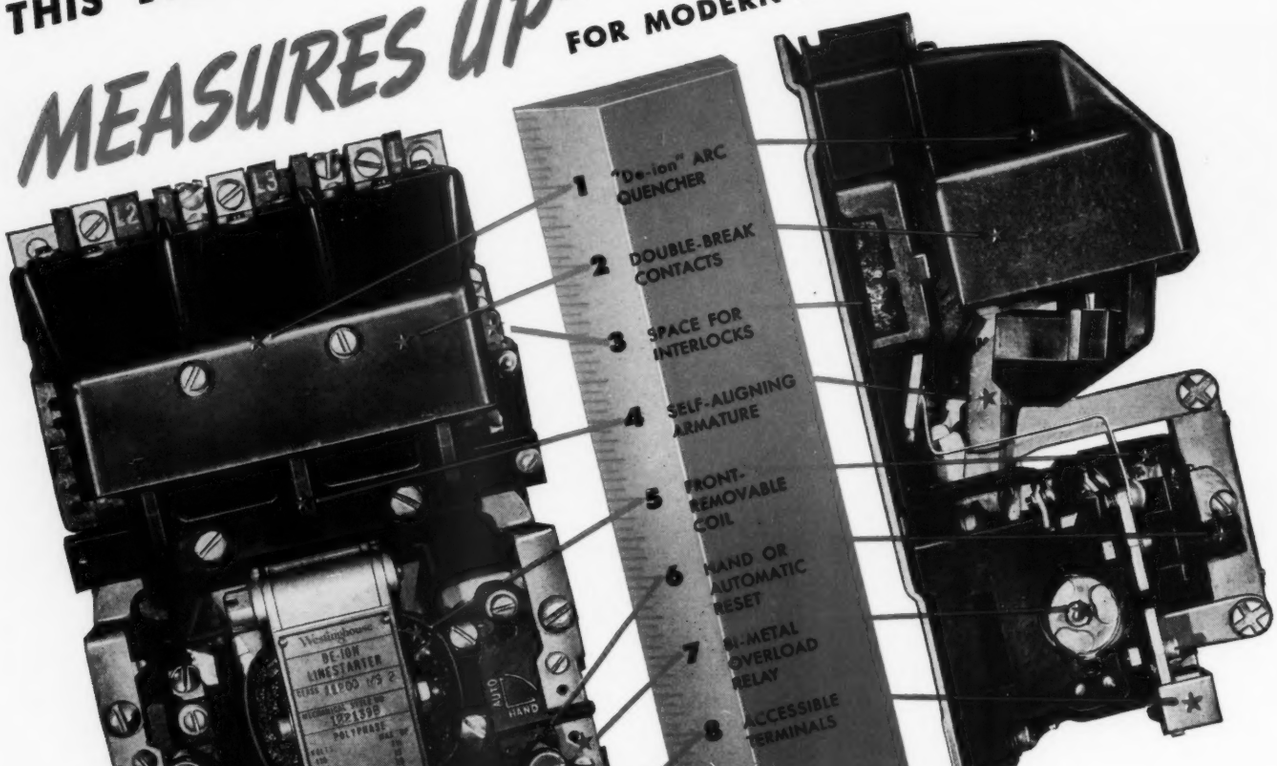
Sales Offices in Principal Cities

NATIONAL STEEL

Division of
NATIONAL STEEL CORPORATION
Executive Offices · Pittsburgh, Pa.

SCRAP IS VITAL TO STEEL PRODUCTION . . . GET YOURS IN FOR VICTORY!

THIS NEW SIZE 2 LINESTARTER MEASURES UP TO ALL REQUIREMENTS FOR MODERN MOTOR CONTROL SYSTEMS



WHAT THESE NEW FEATURES MEAN TO YOU

1. "De-ion" action quenches the arc, prolongs contact life.
2. Double-break contacts eliminate shunts which fray and break.
3. Interlocks—as many as four—can be easily added.
4. Armature keeps true alignment of contacts, does not "wobble" with age.
5. Operating coil easily changed—front removable.
6. Overload relay may easily be made manual or automatic reset.
7. Bi-metal overload protection assures unchanging accuracy. Size 2 heaters are interchangeable with sizes 0 and 1.
8. Speedy installations . . . "straight-through" wiring.
9. Simplified design for group mountings.

Here's a new yardstick for judging motor controls—the NEW Westinghouse Size 2 Linestarter. It's totally new—redesigned to meet the space and operating requirements of today's machines.

Over-all dimensions are now smaller—making it ideal for group mountings and built-in applications. Yet there's no crowding—all parts and terminals are easily front-accessible.

The overload relay may be made either manual or automatic reset simply by twisting the relay reset button—nothing to remove or adjust.

In addition, this new unit has many other exclusive Westinghouse advantages. There's the safety of "De-ion" arc quenching and the dependable accuracy of Bi-metal overload protection. Write today for Bulletin 3185, giving complete details on the new Westinghouse Size 2 Linestarter. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.. Dept. 7-N. J-21253

Westinghouse MOTORS AND CONTROLS

NEW *Book of Facts* ON AIRCRAFT TUBING

WHAT do you want to know about aircraft tubing? Get this new bulletin of facts and you can find most of the answers. It includes a convenient digest of government specifications, and various other data on aircraft tubing which will be found helpful to both designers and builders of all types of aircraft.

Main Features:

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Weights, areas and mechanical properties.

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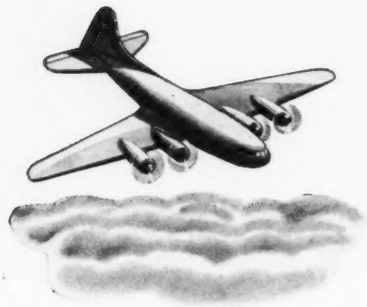
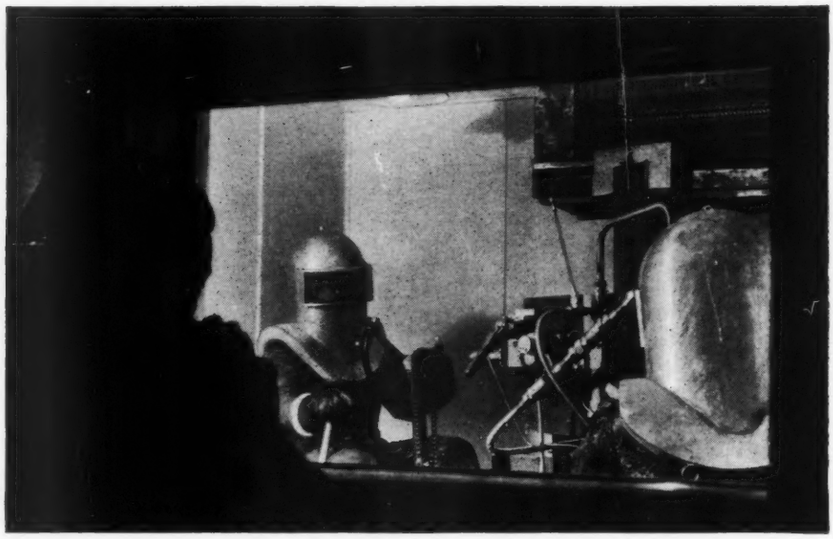
UNITED STATES STEEL

GLASS HELPS BRING THE STRATOSPHERE *Down to Earth!*





Six . . . seven . . . eight miles up. Up in the stratosphere. Soon our flyers and planes will be streaking through heights fit only for angels, before.

Because these heights do strange things to men and machines, industry is untiringly testing the performance of special motors, instruments and parts under actual stratospheric conditions. It is also seeking facts that will help medical science protect the men who rise to these rarefied heights where concentrated oxygen must be breathed and —100° cold combated.

Large testing chambers, like the one in the Douglas Aircraft Company plant, pictured above, bring the extreme temperature and atmospheric conditions of the stratosphere down to earth. These chambers are built with large glass windows so that work inside can be observed.

Because of the bitter cold inside, this would have been one of the most difficult windows in the world to glaze if it had not been for a remarkable Libbey·Owens·Ford glass development . . . Thermopane.

Thermopane might be likened to an air-conditioned glass sandwich. It is made of multiple panes of glass bonded together in one unit. The air space between each pane of glass is dehydrated and sealed. This unusual insulating window eliminates condensation between panes, even under conditions of extreme cold. No dirt nor dust can get inside the glass to impair vision. In short, Thermopane, for the first time, provides a glass window that insulates and affords the clearest vision at the same time.

Today, Thermopane is making an important contribution to the war effort. Tomorrow, this new glass unit, perfected by Libbey·Owens·Ford, promises to open the way to revolutionary benefits in the fields of clear-vision insulation and window conditioning for postwar construction.

Libbey·Owens·Ford glass research is multiplying the usefulness of flat glass, both for military and civilian needs. One of the many types of L·O·F flat, bent or tempered glass products may be the answer to your product problem. May we help you? Libbey·Owens·Ford Glass Company, 1396 Nicholas Building, Toledo, Ohio.

L O F

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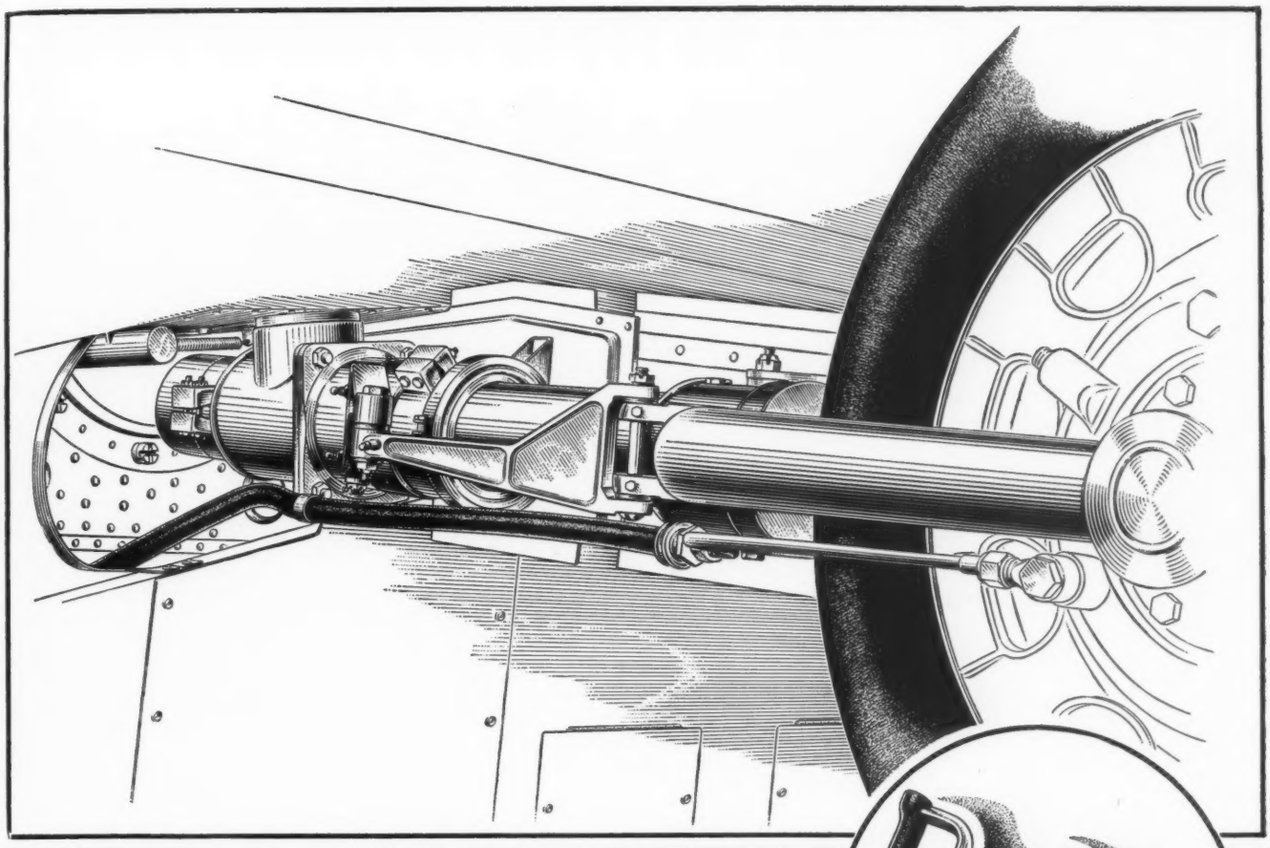
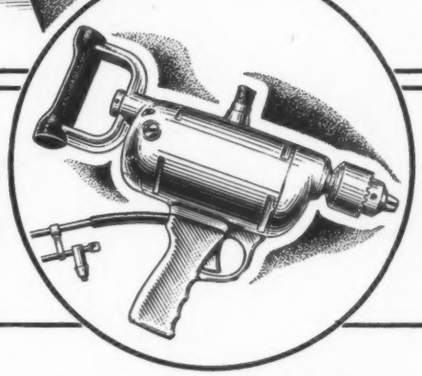


what the Landing Gear Learned from the Portable Drill



IT'S A LONG WAY from portable tools to fighter planes—but an idea that works in one often proves just as good in the other.

That's the way it was with the Torrington Needle Bearing. Portable tool builders quickly saw how its unusual features could be used to cut excess ounces out of their product designs—where *every* ounce counts in conserving the operator's energy, in increasing his efficiency.

These same weight-saving features also caught the attention of the airplane designers. When they needed a bearing that would give easy operation to retractable landing gears...stand up under the terrific impact when three tons of fighter plane hits the runway... and still meet the rigid weight requirements of fast, maneuverable aircraft, they found just what they wanted in the Needle Bearing's unique combination of low friction coefficient, high load capacity, and small size—plus its ready availability for war applications. That question of size is doubly important when it comes to weight economies. It means light weight in the bearing itself, of course. But much more important is the fact that housings and other parts can also be made smaller and lighter.

ISN'T THERE AN IDEA HERE FOR YOU TOO, as you get your post-war designs under way? This light-weight trend looks increasingly important, with freight-by-air looming up as the coming means of shipment. While you're studying ways to conserve weight in *your* products, see how well the Needle Bearing fits into your problem. You will find the preliminary information you want in Catalog No. 108—and Torrington engineers will help you in adapting the Needle Bearing to specific applications.

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New York Boston Philadelphia Detroit
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KEYED TO TODAY'S NEEDS

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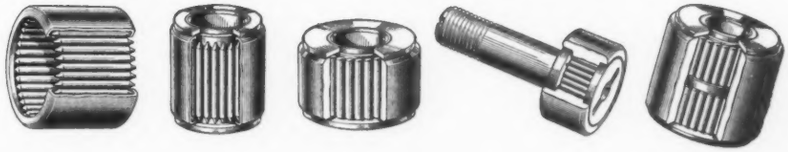

VICKERS HYDROMOTIVE CONTROLS PROMOTE SAFETY

Accident rates increase in times like these when unskilled workers must be hired to operate production machines. Machines equipped with Vickers Hydromotive Controls help to keep down accident rates.

Vickers Hydromotive Controls are simple, easily mastered and offer less opportunity for accident-producing mistakes. Completely automatic cycles are easily set up. Overload protection is positive and automatic. Controls may be so interlocked that incorrect operation sequence is impossible. Vickers Controls can be operated with one finger and can be placed wherever most convenient for the operator. As a result, the operator is not subjected to nervous or muscular strain.

All of these factors tend to reduce accident rates, increase production, reduce work spoilage, eliminate damage to machines. Vickers Application Engineers will gladly consult with you on specific machine requirements.

VICKERS *Incorporated*

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Power—Giant Arm of Production

Ninety Per Cent of American Industry Is Electrified

ELECTRICITY is the mainspring that turns the wheels of our factories, mills and mines. It is the tireless arm that grinds our grain, weaves our cloth, pumps our water, builds our planes, our guns, our ships, our cars, our trucks and tanks . . .

The mighty Pharaohs had less energy at their disposal in building their pyramids than is generated today by one single power plant. The combined capacity of America's central power systems is without parallel in the history of the world . . . 46 million kilowatts, i.e., 65 million horsepower in steam turbines, hydro turbines and other prime movers. That is more power, day in and day out, than 650 million slaves could produce—for a limited time—minutes in fact.

The capacity of this vast fountain of energy is beyond the grasp of the average man who flips a switch and sets in motion machines that perform the labor of a thousand man-hours in a matter of minutes. Perhaps only the old time farmer, whose traditional source of power is a team of tired horses and a pair of calloused hands, knows how to appreciate this commodity that is so vital an ingredient of everything we consume and use.

Yes, we take electricity for granted. We expect it to appear in unlimited quantities, like water and air, as we need it. Almost as essential as these two elements in times of peace, it becomes a matter of life and death in times of war. Industry would collapse without it and the nation would quickly perish.

With the catastrophe of Pearl Harbor a little over a year ago, came the realization that we had to out-produce our enemies. To out-produce our enemies, who had a seven year head start, meant to turn more wheels than they were turning and to turn them faster than they were turning them.

New plants sprung up overnight. Production increased beyond our wildest dreams. Aircraft and shipbuilding surpassed the most daring forecasts. The machine tool industry's output grew to a volume that bordered on the miraculous. Guns, shells, uniforms, shoes, tanks and a thousand other items were being made in hitherto undreamed of quantities. All of them have one common essential ingredient – power. Industry demanded power – more and more power!

It is no small tribute to the power industry that, while other raw materials developed shortages necessitating strict priorities control, electricity remains unrationed – no priorities, no curtailments, no rate increase. Current industrial consumption is running 16 per cent over 1941 and 50 per cent over 1940. Not spectacular perhaps but when we consider that the nation's 26 million domestic consumers utilize only about 14 per cent of the energy output, we begin to get some idea of industry's power consumption.

Our power companies might have been stunned by the prospect of mounting demands for kilowatts. Instead they set about developing and coordinating a multiplicity of relatively small and seemingly unrelated factors. Individually or even collectively, these have not been of a spectacular nature. Certainly they have not inspired the award of the Army-Navy E although they are an essential ingredient in every Army-Navy E that has been awarded to American industry.

The contribution of the power industry to the winning of the war is not likely to flame forth in newspaper headlines. It takes the more prosaic turn of portraying an industry that is doing wonders quietly, unobtrusively.

At the close of the last war the power at the disposal of the American industrial worker averaged 3⅓ horsepower. At the beginning of this war, twenty years later,

This is the seventh of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers, and in daily newspapers in New York, Chicago and Washington, D. C. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

it had increased to 6½ horsepower. What other nation can even approach that figure? This large provision of power is the achievement of the electric utility industry. For years it had built and applied its equipment to the highest standards of performance and operated its systems to equally high standards of service and dependability. Always recognizing that "public service is a public trust" it had maintained wide margins of security in performance. Today these margins are the source of the power industry's ability to rise to the emergency.

In short, the electric utilities were prepared!

Power men are accustomed to looking ahead, to prepare for growing loads and allow for unforeseen contingencies, for electricity cannot be stored. It is "ordered" by touching a switch. It is delivered and consumed at the same moment.

Months before the actual outbreak of hostilities foresighted power men set to work computing how much life of equipment could be risked in the process of crowding it toward greater output. Generators, boilers, turbines, cables, transformers and even conductors underwent close scrutiny in an effort to increase the load – *safely*. They figured, they experimented, they tried untried measures.

Insulation, for example, is the crux – the least known component of electrical apparatus. When it lets go the service suffers. It is not easy to know how near any bit of crucial insulation is to letting go. It takes courage to work it to a point just short of failure . . . but that is exactly what is being done today.

Technological forcing of equipment, however, is not all of the story. Obsolescent equipment has been rehabilitated; salvage has been intensified; critical metals have been replaced by non-critical materials; water sprays, air-blowers and other cooling methods have been installed to keep over-loaded apparatus from over-heating. Nothing has been overlooked. Ingenuity has contrived the well nigh impossible.

Hand in hand with these measures of expediency have gone measures of intensification. Hydrogen pressure for cooling generators has been stepped up from ounces to pounds taking more heat away from the machines and enabling them to carry greater loads. Capacitors – little more than aluminum foil interleaved with thin paper – have been applied by the carload relieving the systems of that mysterious reactive current which is associated with that equally mysterious power factor. They have performed wonders in avoiding the need for additional generating and transforming equipment. The use of portable sub-stations has averted the otherwise necessary reserve capacity in fixed installations at many points.

When coal was placed on the urgent list last spring the electric utilities outstripped all other industries in providing storage for the winter. Stocks on hand the first of October were sufficient for 105 days, or more than twice what would be considered adequate in times of peace.

When staff losses to the armed forces became serious power companies contrived measures that enable them to get along without aggravating the national manpower situation by hiring others to replace them. Today meters are being read every two or three months instead of monthly; women are being trained to do drafting, keep the logs in power plants and sub-stations and to test meters in shops and laboratories.

On the summit of "Grandpa's Knob", a mountain overlooking Rutland, Vermont, stands a giant windmill that would have been the delight of Don Quixote. Towering 200 feet above the tree tops its mighty 175 foot propeller turns with the wind and drives a 1,000 kilowatt generator which feeds its output into the Central Vermont Public Service Corporation's power system. The most ambitious wind-turbine generator in the world, and a daring experiment of forward-looking men.

Today everything electrical is being tried; is being worked harder than it has ever been worked before.

Great credit is due the men behind the electric power industry. These men have recognized the responsibility of their jobs – it is a part of their very being. Theirs is the kind of service that *must* be maintained. No soldier is truer to his trust than is the employee of this great industry.

The service must go on! No matter what happens – acts of God or deeds of men – the service must go on! Labor disturbances may disrupt other industries but there have been no shutdowns due to labor trouble in electric power plants since Pearl Harbor.

And this winter when blizzards pile up drifts and sleet makes pavements slippery there may be absenteeism from other plants but the utility employees will be on the job ready to climb the ice-covered poles and repair the ice-laden lines whenever the call comes.

In this war the least costly yet the most precious element of production – electricity – will be ever ready to "man" the machines that will produce the weapons that will give victory to the forces of freedom.

President, McGraw-Hill Publishing Company, Inc.

PRODUCT ENGINEERING

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IN THIS ISSUE

Camouflage Is a Design Problem

Never before has camouflaging been used so extensively and applied to such a wide range of objects. Soldiers, searchlights, trucks, planes, airports and whole cities are being disguised by an art that has leaped suddenly to new heights of perfection. Unquestionably, after the war when the full story can be told in detail, some of the materials and techniques now being developed for camouflage will find direct or indirect application in peace-time products. New paints and new principles in blending form and color will be heritages which the industrial designers of the post-war period will undoubtedly apply to advantage.

In the article beginning on page 6 will be found a wealth of information on the materials and techniques of camouflage. Of course, the whole story cannot be told now but readers will find the article not only fascinating but informative as well, particularly with reference to the newly developed paints being used.

Electrostatic High-Frequency Heating

The impossibility of curing thermosetting plastics uniformly has been, up until recently, a definite bar to the production of such plastics in thick sections. It has also limited the maximum thickness of resin-bonded plywood to about 1 in. Now, however, by the use of electrostatic high-frequency heating, resin-bonded plywoods as much as 148 laminations thick are produced with all of the resin glue cured to exactly the same degree. As explained in the article beginning on page 40, there is no temperature gradient in electrostatic heating and the process can be applied to any material that is a non-conductor of electricity.

Flexible Vinyl Plastics

Sheetings of flexible plastics have and are being used by designers of products for applications which when

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in service are subjected to intermittent abrasive action. In the article "Abrasion Resistance of Flexible Vinyl Plastics," see page 45, by F. W. Duggan of the Plastics Division, Carbide and Carbon Chemicals Corporation, considerable test data is presented that fills a long felt need. The article describes test apparatus and testing methods from which were compiled comparative data on abrasion resistance of vinyl sheetings, rubber and leather.

Mobile Fire-Pumper

Civilians and governmental agencies are alert to the possible hazards of war on the home front and are busy inventing ways and means of combating emergencies which if uncontrolled would result in severe economic losses. One example of equipment that is now available for the protection of property is the Chrysler War Emergency Fire-Fighting Apparatus, see page 12.

Stress Concentration Factors

Practical use of measurable factors affecting stresses in loaded machine parts has been handicapped by lack of published articles written with the object of aiding designers in applying them. George H. Neugebauer, Department of Machine Design, Cooper Union, recognizing this need, has this objective in his article on page 31 in which he simplifies the job of choosing design stresses and removes some of these problems from the realm of guesswork and empirical practice by showing how to use design formulas in determining several kinds of stresses.

Conversion Linkages

Mechanisms that were designed for conversion of one type of motion to another or from electric, hydraulic, pneumatic, or other type of impulse to mechanical motion for recording instruments, can be adapted to heavier machinery by modifications which will be suggested by study of two pages of typical linkages in such instruments. See page 38.

Better Magnets

A steel capable of carrying one-third more flux than the best grades of silicon steel, now used in transformer cores, and the development of a new method of fabricating cores of this material are described by C. C. Horstman, Westinghouse transformer engineer, on page 28 who points out their value in either improving transformer performance or reducing their size and weight.

Open Shell Structures—II

In order to round out and complete the analysis of stress distribution in open shell structures when subjected to torsion, which was presented in December 1942 P.E., E. H. Spaulding, structures engineer at Lockheed Aircraft, presents in Part II, page 25, an illustrative example with test data that was obtained from an experimental structure. Theoretical calculations are made in accordance with the discussion as outlined in Part I and then compared with test results obtained from the model structure.

Magnet Coil Life At High Temperatures

Magnet coils that are designed smaller to conserve critical materials heat up more rapidly, but whether or not the resulting higher operating temperature will seriously affect the life of the coil depends on a number of factors, as explained by Graham Lee Moses in the article beginning on page 22. Curves illustrate the relation of voltage, duty cycle and winding space on temperature rise and coil life.

A Mouse in the Loft

The square and magnifying glass, used in conjunction with a stretched music wire for laying out long straight lines, have been replaced on the Fleetwings lofting platform by an electrical feeler device that locates connecting points for the straight edge with greater ease and speed. Since it resembles a mouse in appearance it goes by that name. See page 24.

Safe Beam Loading

Since the method of loading beams has much to do with making best use of the strength of beams, Marshall Holt, Aluminum Company of America, describes loading tests for 17S-T tubular beams that produce results in terms of modulus of failure comparing reasonably well with previously published data under certain loading conditions, which are defined in his article on page 36.

Flexible Chart for Moments

Rectangular moments of inertia and section moduli of several common shapes of section can be determined by use of the single nomograph on page 61. The chart is convenient for comparison of various shapes in a given application as well as for determining different proportions of any given shape that may be most suitable for the desired service.

WHAT'S COMING

Brazing By Induction Heating

As a fitting companion to the article on electrostatic-heating appearing in this number, February P.E. will have a comprehensive article on brazing by induction heating. This further application of the induction heating process has opened new fields for the designer.

New Color Standards

The American Standard Association recently announced the new standards by which colors are definitely and accurately specified by numbers and symbols. No longer will color matching depend on inaccurate visual comparison. Using the color analyzer and the A.S.A. standards, the engineer in the future will designate his colors as specifically as he now selects his alloys. February P.E. will explain how it is done.

Dimensioning Tolerances

The worst difficulties encountered in our mass production interchangeable manufacturing system are caused by improper dimensioning. The problem is aggravated when tolerances must be specified for successive machine operations such as tolerance dimensions for milling and then the same piece dimensioned for finished tolerances after grinding.

S. C. Bliss in February P.E. will present in simple form a quick check by which the correct dimensioning will be assured.

Clutches With Powdered Metal Faces

Clutch and brake linings made of sintered powdered metals welded to a steel backing have won places in the whole range of light to heavy-duty service, as the result of their long life and smooth, positive performance. S. K. Wellman Company engineers, who are constantly developing new materials for special applications and maintaining tests on performance, will tell next month about the properties of the materials, how the linings are made, the tests they go through, and their effect upon brake and clutch design.

offered prices are reminded that under the War Powers Act, their metal may be confiscated for a 50 percent down payment. The owner may sue after the war for as much more as he thinks he deserves. If the owner still is recalcitrant after that has been explained, a deputy U. S. marshall is sent to take physical possession.

Excess inventory—any more than a fabricator requires to fill authenticated priority orders for the next 90 days or more than a distributor sold during the four preceding months—is compiled weekly by the Copper Division and mailed to 100,000 war suppliers. Fabricators who find the material they need in the list are put in touch with the owner. Copper which can't be exchanged thus is allocated for scrap or remelting.

Inventories of copper screening were second to be polled and holders of insulated copper wire were third. Plumbing, heating and roofing concerns are in line for study now if they have not already been solicited. Insiders say that WPB will start to round up all copper-bearing ornamentation by mid-1943 if the war-born demand does not show signs of slackening by then.

MANPOWER CONTROL AT LAST

The presidential edict which gives Paul McNutt power to transfer workers from non-essential to essential industries may result in shifting of design engineers to war work, and conceivably could affect some already so engaged.

Such transfers would be enabled by the clause which provides that "no employer shall retain in his employ any worker whose services are more urgently needed elsewhere." This unquestionably will have to be effectuated by some sort of manpower priority system, and technical as well as manual workers will be affected. Designers already on war work will be affected in so far as their activity is regarded as less essential than other war activity.

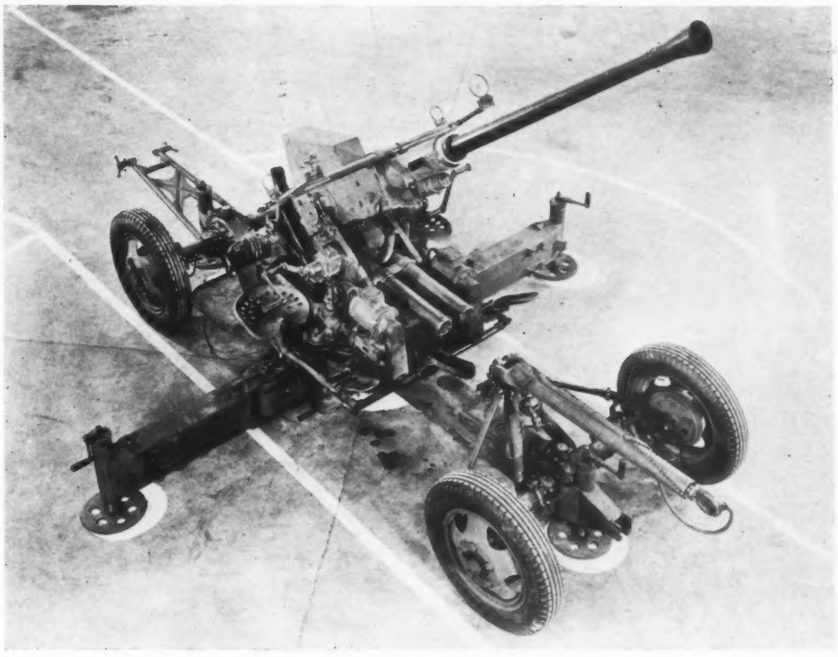
For the present, such transfers will remain on a voluntary basis and be confined to those areas in which labor supply is critical. One problem of the past which is due to be acted upon is that posed by conflicting rulings on similar circumstances by different local draft boards. McNutt says equal emphasis will be placed on proper allocation of workers and on filling draft calls.

REDESIGN FOR LIVING

Civilian economy is in for the same drastic going over that the Army's Ordnance Department is giving war materiel, although the new blitz on business as usual probably won't entail as

U. S. Army Signal Corps

M-7 tank destroyer, the Army's newest, mounts a 105 mm. howitzer and a .50 caliber machine gun, the latter principally for antiaircraft defense. Essentially this is the chassis of an M-3 medium tank with the guns and superstructure replacing the armored top gear of an M-3



Redesign of the carriage of the 40 mm. Bofors antiaircraft gun as described in a paper by Dr. J. L. Miller, chief metallurgist, Gun-Mount Division, Firestone Tire & Rubber Company, won for the author the second grand award of $11,200 in the welding study program sponsored by the James F. Lincoln Arc Welding Foundation. Chassis and outrigger supports were designed with high-strength, low-alloy steels. The top carriage, which carries the gun, and other smaller parts were redesigned for welding. Results, aside from an estimated total saving of $171.43 per carriage, are faster production and better performance, the latter largely by virtue of the decreased weight.

much actual redesign as the services have engaged in.

At least some of the aims are similar, for WPB wants to save manpower, materials and machine time for more essential use. The Office of Price Administration, which is letting WPB carry the ball, is interested in stretching the supply of civilian goods, controlling quality standards to prevent hidden inflation and eliminating enough lines to simplify price control.

One fundamental difference between the Ordnance program and that under development for civilian production is that while the Army is eager to obtain quantities of any new development which will aid in winning the war, WPB and OPA are not interested in augmenting the civilian standard of living. Actually, with the two agencies in agreement on the idea that simplification and standardization are musts for the civilian economy, frills and luxuries in essential civilian goods are in for a severe axing.

Little-used grades will rapidly be junked, along with those ingenious dingbats which help sell an article in a competitive economy but without which a product is still usable. Thus far, WPB has issued more than 60 standardization-simplification orders and another 150 or more are in the works. Industry is consulted in the preparation of these orders, as is the National Bureau of Standards or the American Standards Association when necessary.

NEW LIBERTY SHIPS

Not all the military and naval successes of the late fall were in the Solomons or North Africa. The Maritime Commission, for instance, was so well pleased with the war against submarines that it spoke publicly about post-war possibilities of the new type Liberty ship it has been designing for a year and now has under construction.

Of course, equally prominent mention was made of the fact that the new ship will have enough more speed to render it less vulnerable to submarine attack, but the fact that post-war competitive possibilities were mentioned at all may be considered significant. Only last August marine insurance rates, a realistic barometer whence shipping dangers may be calculated, reached a high of 25 percent for the New York-Buenos Aires run. They have since slumped to half that figure.

Cartoon by Bill Hild, Hughes Aircraft Corp. Available through arrangement with the National Aircraft Standard Committee, Aeronautical Chamber of Commerce of America, Shoreham Bldg., Washington, D. C.

MATERIALS

Phenol shortage worried producers into widespread discussion of extenders which lower quality but stretch supplies. At the same time, producers asked WPB to keep them supplied with sufficient raw materials to fill authorized allocations of their end products.

Direct military requirements for vinyl resin coatings will require more of certain grades than now are available, and considerable substitution is to be expected. Vinyl chloride types probably will have to be used in place of the preferred vinyl butyral for Army raincoats and similar applications. Experiments are being made with certain vinyl resin polymers as adhesive substitutes for crude latex.

Use of zinc has been further curtailed as shortages outlawed less essential uses. Health supplies, precision instruments and dies are still unrestricted, and curbs have been eased on use of zinc in functional and mechanical parts of gasoline and diesel engines. No items on list A or A-1 of Order M-11-b, as amended, may be coated with zinc or made from zinc-coated metal. Zinc for automobile parts and building and industrial material is further restricted.

The Steel Division wants customers to study their needs for possible replacement of open hearth steel by Bessemer or re-rolled rail steel, which WPB says is not being used most effectively.

Complete allocation control has been established over tungsten wire, rod, sheet and powder.

Stainless steel may be used in several products, including boiler casings, heaters and radio antennas, for the armed forces. More items may be added to the exempted list. Corrosion or heat resistant chrome steel now may be delivered only on ratings of AA-5 or higher. Stocks on hand may be used only if acquired on AA-5 ratings or better.

WAR MATÉRIEL

Design • Developments

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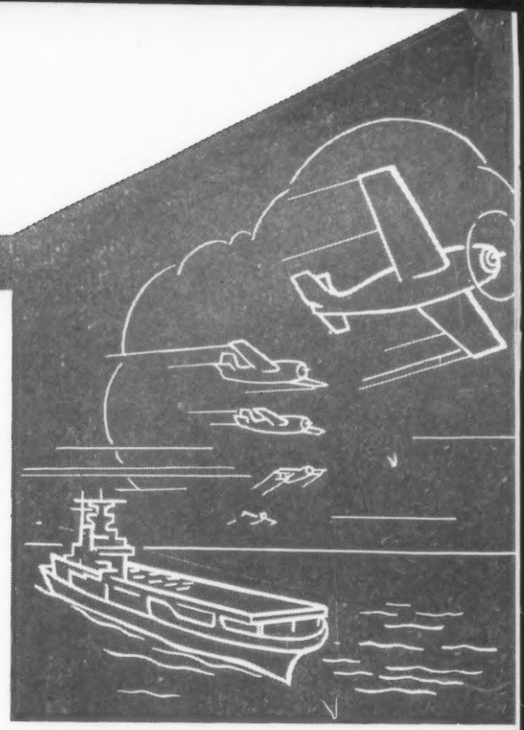
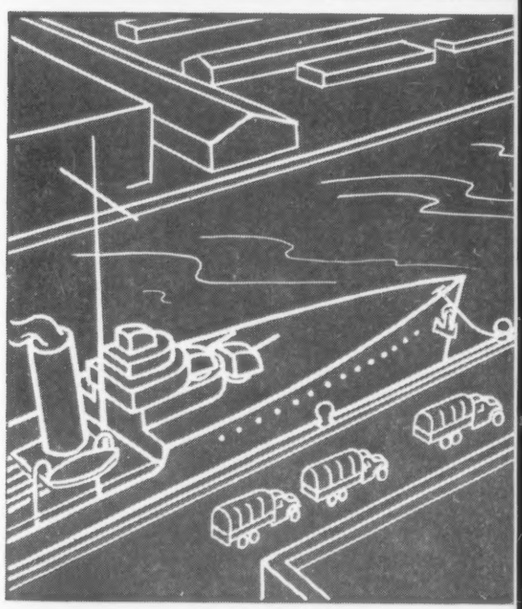
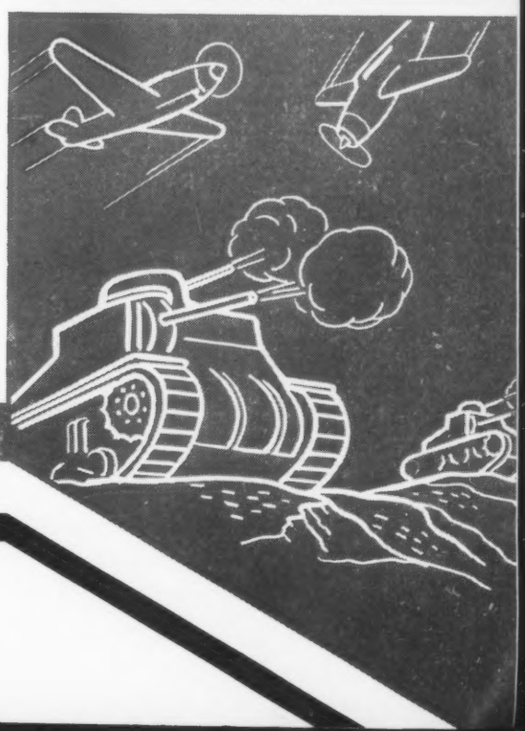
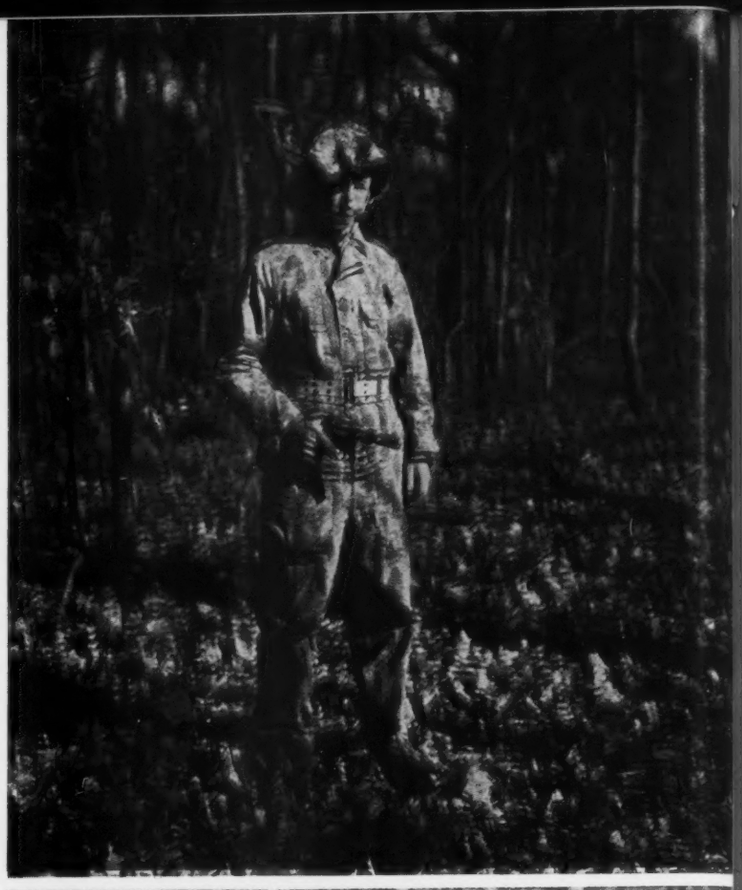








CORPORAL Glyndon Wolfe putting on his "shoot-suit," camouflaged helmet and shoe coverings. Grease-paint on his face and rifle camouflaged completes disguise. Two-piece suit is reversible, tan-orange for fall or winter, green-brown for spring and summer. In our cover picture Corporal Wolfe is lying less than 20 ft. from the camera; at 50 ft. he would have been invisible.

Camouflage Is A Design Problem Requiring Imagination Plus Skill

Materials and techniques of the art of camouflage as used for hiding soldiers, guns, trucks and planes, and disguising plants and cities, are described in this article. Information and data on the paints and materials used and their relative costs are included.

IN JUST the same fashion as the designer must combine materials into the most efficient product that may be had within given cost limits, the camoufleur must adapt more limited materials to a given terrain with available labor in the available time. Principal difference lies in the stakes. The industrial designer works against an economic bogey. The camoufleur counts his mistakes in the lifeless bodies of fighting men and blasted material.

Stacked up against the tools of other fighting men, the camoufleur's four material weapons—nets, garnishings, paints and decoys—look out of place in the combat zone. They are useless without the most important single tool at the camoufleur's command—a vivid imagination controlled only by an intimate knowledge of the art of reconstructing natural scenes and a passion for detail.

The camoufleur works under an elastic code bounded only by such principles as the fact that normally it is more effective to do a real job of fooling the enemy than it is to try to hide an installation completely. Elaborate arrangements to hide large installations are more vulnerable targets for the enemy, who will study aerial photographs in search of the one, picayune mistake which will give away the whole thing. Those smaller camouflage jobs which blend installations into the terrain and are made hard to find and difficult to focus upon are better because they have fewer flaws to show up under photographic scrutiny.

Fooling the Bombardier

Camouflage designed to protect areas subject to artillery fire must be proof against all types of observation. Camouflage for areas not subject to artillery fire, which for the present at least may be considered to mean virtually all of continental United States, need be proof only against direct observation by bombardiers. This simplifies the problem considerably and lends weight to the maxim that to protect against aircraft, the principal job is to fool the bombardier rather than to hide his target completely.

Normally, the bombardier has only seconds in which to make his calculations and frame his target in the sight. If by protective concealment the camoufleur can fool the bombardier and cause him to scatter his bombs widely or necessitate a second run over the target, additional time is obtained for ground defenses to adjust their fire and for interceptors to get into action.

Shadows Vital to Camoufleur

Form, shadow, texture and color are four means by which experts poring over aerial photographs can make out the identity of ground installations. Hiding, blending or deceiving are three means of preventing such identification.

In nature, few forms are regular. Appearance of regular forms on an aerial photograph of an area which the enemy is known or believed to have occupied is prima facie evidence of enemy activity. Thus, any camouflage must break up regular patterns by hiding them, blending them into surrounding terrain and its natural cover or by fooling the observer into believing that they represent something of no military significance.

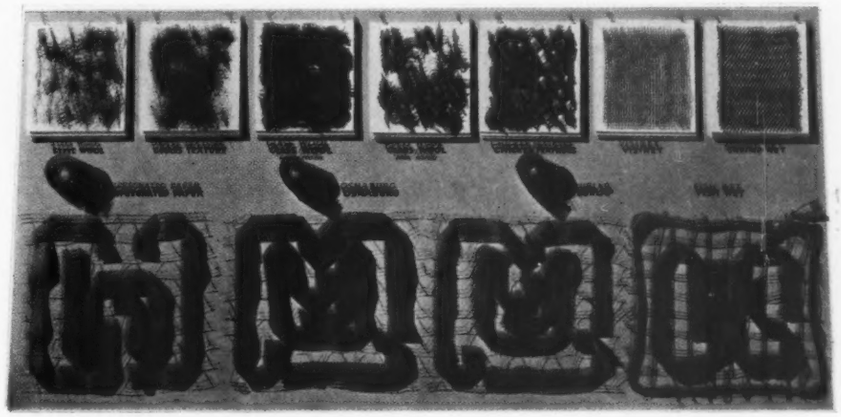
Each object casts a typical shadow. The camouflage job which hid a field piece and left its shadow for all to see would be a waste of time and material. Thus, shadows are vital to the camoufleur, are an ally when properly used and a deadly enemy when handled carelessly. They must be broken up into irregular patterns which reveal nothing to the student of aerial photographs.

Texture is vital because of light reflectivity. Smooth surfaces reflect more light than rough surfaces. Standing vegetation is irregular, casts shadows and absorbs light. Roads, paths and bare fields are regular and reflect much light. Camouflage must be matched to the area it would hide, otherwise it would reveal instantly the presence of artificial protective installations.

Color Problems

Color presents much the same problem as texture. Camouflage installations which present a yellow surface staring out of a green field or woodlot are easily discernible by direct observation or aerial photography and constitute an invitation to the enemy to see what a stick of bombs can turn up.

Successful camouflage requires proper choice of position and materials, proper



Some of the materials that the camoufleur has to work with are shown here, they include steel wool, glass wool, chicken feathers, impregnated paper, osnaburg, burlap, chicken wire and various forms of netting

erection and maintenance. Troops must be "camouflage disciplined" so as not to impair effectiveness.

A good position must not only enable the occupying troops to accomplish their mission, but must also be such that in reaching and supplying it they leave a minimum of telltale tracks. The position must be one which offers at least some natural concealment or the greatest possible ease of concealment by camouflage, and its layout must be such that accessory positions can be established close enough for proper military activity, but not so close as to reveal the main position. Study of aerial photographs, maps and ground reconnaissance is necessary to choose the best available position. Terrain should be as intricate as possible rather than regular, containing woods, shrubs and folds. Sizeable bodies of water should be avoided.

Materials used to conceal the position should match the surrounding terrain in color and texture, and must be chosen with an eye to the maintenance problem they will present. Natural materials are best for temporary or short-lived positions as regards color and texture, but their use presents a more burdensome maintenance problem than do artificial materials and the greater erection time necessary may preclude their use.

Good camouflage discipline requires that occupying troops must not leave tracks in surrounding terrain, must not cut trees or sod, wear paths or otherwise indicate presence of foreign activities in the area. It requires also that camouflage must be kept in repair, changed with the seasons, repainting as it weathers and replaced as it is damaged.

Proper erection must break up all telltale shadows and substitute for them an indiscernible shadow pattern. It also must hide the form and shadow of the camouflaged object, and it must hide those marks left by erecting personnel. In carrying out all these qualifications, camoufleurs must bear in mind constantly that most aerial photographs are taken from a height of 1½ to 3½ miles, so that work must be planned and executed on a scale in proportion to these distances, with proper perspective embodied in the installation as well.

Camouflage materials fall into two classes, natural and artificial. Natural materials are green and dry vegetation and debris. Artificial materials include the aforementioned nets, garlands and paints.

Natural Materials Better

Natural materials match surrounding terrain and its natural covering better than artificial materials, are effective against all types of photography, particularly infra-red and color, and they reduce the quantity of artificial materials which must be supplied from the rear. On the other hand, natural materials may not be prepared in advance for rapid installation, and green vegetation must be replaced often, with a considerable increase in work and the possibilities of poor camouflage discipline. In general, natural materials give best results. However, artificial materials find considerable use in positions which are more or less permanent and in which constant replacement of green

Real tree branches and saplings mingled with imitation trees made of osnaburg garnishing hung on wire frames effectively camouflage the slag roof. Additional garnished wire frames cast varying shadows on the mottled pattern of paint spots

vegetation would be too great a task, in situations in which time and labor are not available for gathering and erecting natural materials, or in which suitable natural materials may not be gathered without enormous difficulty.

Both textile fish nets and chicken wire are used as netting in artificial installations. Fish net carries less load, shrinks in wet weather and expands as it drys and deteriorates much more rapidly than chicken wire.

However, fish net is lighter than chicken wire and more easily transported. Its mesh may be of varying size and its color pre-fixed to meet specific conditions. It is considerably easier to handle and may be used in positions requiring a draped installation. Chicken wire in any quantity requires a wire frame, but it can bridge longer gaps without sagging than can fish net. Also, it will not drop the whole covering onto men or materials beneath in case of fire.

Osnaburg cloth, a heavy, coarse-weave cotton fabric, is preferred to burlap for garlands by some Army men because burlap has a tendency to unravel in the wind when torn into the 2½ in. strips normally used for garnishing.

Another method of garnishing is to smear a mixture of chicken feathers and bituminous adhesive, or other adhesive, over chicken wire. This presents about as irregular a surface as has yet been found.

Currently, Army engineers are receiving reports on an impregnated paper substitute for burlap and osnaburg, for which they admit there is no pressing need. Another substitute is matted cotton batting. Incomplete reports from outfits now experimenting with paper in the field indicate that it is as good or better than burlap or osnaburg with a few minor exceptions.

One of the hitches already encountered with paper is that it is not strong enough to be used with stapling devices currently employed to garnish nets. The machine staples one end of a garland around a net mesh and holds it while the remainder is woven into the desired pattern. Built for osnaburg and burlap, the stapler tears through paper and necessitates hand weaving. Redesign of the stapler to provide a greater contact area on the paper during the weaving process probably would remedy this fault. In the meantime, paper is being held as a substitute, ready for action if supplies of cloth garnishings fail.

Garnished nets may be prepared behind the lines and moved in ready for erection. They may be colored before or after erection, normally by paint spray, since hand painting would be an almost impossibly laborious task and because dipping adds too much to the weight of the finished net.

Solid color nets generally give as good protection as those of mottled pattern, and are easier to prepare. Paint is more satisfactory than dye because it holds its hue for longer periods. Both sides of the garnishing must be colored.

Garnishing is applied most heavily at the center of the net, where about 90 percent of the mesh openings are covered. Toward the edges, garnishing thins out into highly irregular patterns which merge into the irregularities of the terrain and cast merging shadows. Heavier central weaving

Chicken wire being cut to a pattern laid out on the floor, later to be used for camouflaging, such as the roof of a factory. Wire has been coated with a mixture of chicken feathers and bituminous adhesive which gives a durable garnish with unchanging color

Supported so as to present graceful sweeping curves, the two osnaburg garnished fish nets, sprayed with infra-red reflecting paint, effectively break up the shadow and outline of the airplane and blend them with the rolling field

serves to conceal the material under the installation. Chicken wire strips, whose standard width is six feet, are always pregarnished thick for use in center installations or thin for use around the edges.

Oleo-Resinous Paint Used

One of the paints for camouflage work is oleo-resinous with infra-red reflectance. Both of these specifications are relatively new, particularly the infra-red reflectance. Formerly, the major camouflage paint was casein base. The switch to oleo-resinous was dictated by several considerations. It is more readily available than casein base, is cheaper to use despite a slightly higher initial cost because its unit covering power is greater, it is more flexible on textiles than casein and sets, or becomes water resistant, in considerably less time after application than casein.

Only months ago, infra-red reflectance paints were frightfully expensive, even for an army operating on the principle that expense was distinctly secondary. Infra-red properties deteriorated rapidly, and reaction to climatic changes was severe. These failings have since been remedied. The paint now has good lasting qualities and its infra-red properties normally last for the life of the paint.

Principle of infra-red reflectance is the old one of matching up a foreign substance with natural surroundings. Most growing foliage, with the exception of certain coniferous material, reflects infra-red light to a considerable degree and appears medium to light grey when photographed on infra-red film.

Dead vegetation and most ordinary paints or other surfaces reflect no infra-red light, thus photograph black on infra-red film. The error of matching color and texture of natural materials closely but failing to match the infra-red reflectance properties of camouflage installations with surrounding vegetation obviously would be a fatal one.

The infra-red reflectance of a camouflage installation need not be perfectly matched up with that of surrounding terrain. The point is to prevent glaring discrepancies and to break up telltale lines and shadows which would be readily visible if the parts which formed them were not painted with reflectant paint.

In cities, or for industrial installations in the United States, the need for infra-red paint is virtually negligible. For one thing, it would require an impossible expenditure of a necessary material, and for another, foliage or vegetation is generally sparse in an urban area. Thus, widespread use of infra-red paint is confined principally to foreign areas in which deciduous foliage is predominant in the natural covering.

Infra-red paint may be used on rural structures if they cannot be properly handled otherwise and if sufficient paint can be spared to do the job.

Small military items such as oil cans need not be painted with infra-red protective purposes, but they should be of a dull hue. Mobile field equipment should be painted to a medium infra-red reflectancy and of a lustreless hue. Garnishings should have infra-red reflectance, as should landing mats.

An example of the picking and

Infra-red picture taken of a plane camouflaged with nets that have been treated with ordinary paint. Such camouflage is useless for permanent or semi-permanent locations as the enemy would take infra-red photos, spot the camouflage and return to destroy it

choosing a camoufleur must do to ready himself for any contingency may be seen in the report of experiments conducted at any Army center aimed at determining efficient and economical methods of camouflaging airplane runways.

The officer in charge of this experiment mixed such substances as wood chips or blocks, slag, excelsior, gravel, plant-mixed limestone, redwood fibre, pea gravel, leather chips, chicken feathers and pine bough tips in asphalt, then smeared the resulting preparations over runways and sprayed them with standard infra-red paint of a color somewhat darker than the surrounding foliage. (The paint was darker because from the air, man-made installations which apparently match surrounding foliage exactly will show up somewhat lighter.)

Study of the various substances convinced the officer that such installations, if properly applied and maintained, should fool aviators and their cameras at heights of 5,000 ft. or better.

Such substances as pine bough tips obviously would not be used in areas which supported only hardwoods, not because a photograph from 5,000 ft. would disclose the pine bough pattern but because of the persistence for accurate detail which must mark good camouflage work.

Wood blocks and chips proved best for those surfaces on which planes most often make contact with the ground. If it were to be desired to make the remainder of the runway cover of a different material, the line of demarcation might be merged into the ground pattern by cutting grass entirely across the field in such a way that one material matched low-cut grass, the other matched higher grass. Thus, the demarcation line would run completely across the field and would not give away a runway.

Wood chips and stone stood up best under test; slag and stone are harder on tires than wood chips. Wood blocks were laborious to place.

Asphalt was the best single adhesive for such installations. Hot tar, if properly chosen for the job, will prove an adequate substitute, but indiscriminate use of tar is inefficient for a number of reasons, one of which is that tar is more susceptible to weather changes than is asphalt.

The point of mixing foreign substance in with the asphalt is to break up what otherwise would be a smooth, glaring surface pattern. Irregularities, even as small as those provided by pea gravel or leather chips, tend to absorb light, cut down the reflected glare and to cast irregular shadows.

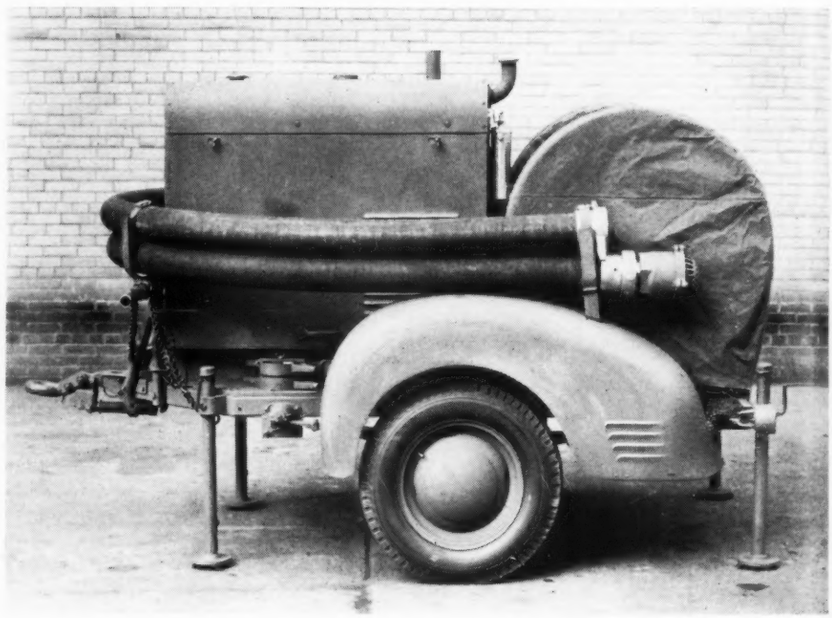
Cost of these preparations, including painting, ranged between 12 and 30 cents a square yard. Maintenance costs would not be too great, but such installations call for constant supervision and maintenance against weathering, seasonal changes in surrounding terrain, and wear and tear. Wood chips were cheapest, plant-mixed limestone the most expensive substance. Installation could be made with men and shovels if necessary, but greatest efficiency would require apparatus used in bituminous road surfacing jobs.

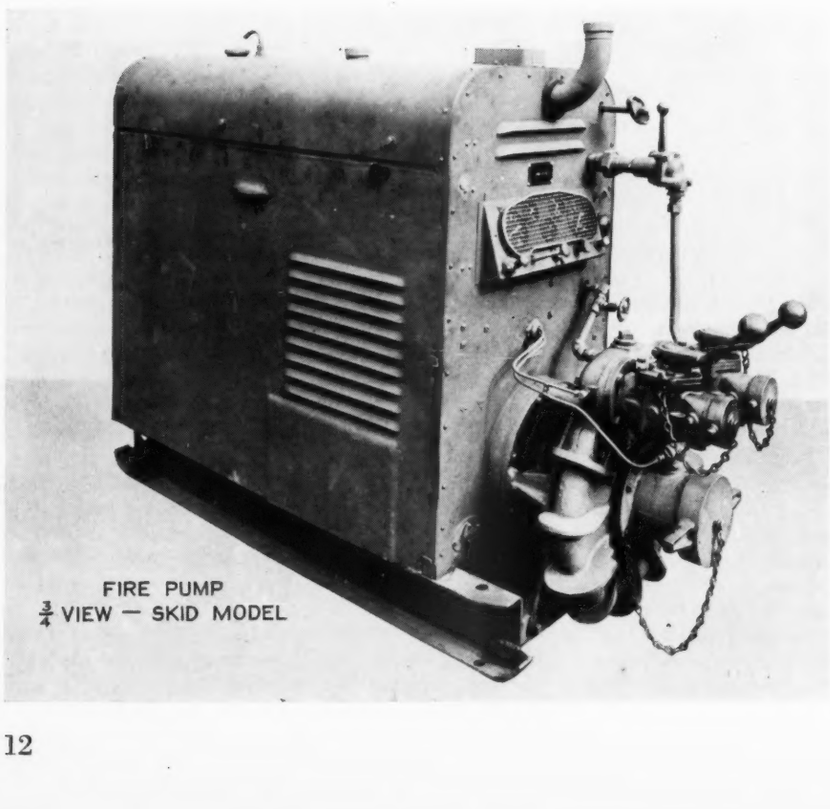
These, then, are some of the materials and principles the camoufleur takes with him to his job. The rest is up to him, and the rules of the game are such that coming close is not good enough.

WARTIME DESIGNS . . .

FIRE-FIGHTING APPARATUS FILLS WAR NEED

Mobile fire-pumper for protecting buildings and property that might be subjected to enemy action or sabotage that would start fires. Light in weight, the pumper can be handled by two or three men. Capacity of the unit is 500 g.p.m. at 120 lb. per sq. in. pressure. The pumper can be mounted on a trailer and towed behind any kind of motor car, or can be skidded and carried in a small truck. The idea for this apparatus originated with Davis A. Wallace, president of the Chrysler Division, Chrysler Corporation. One advantage of the Chrysler units is that a large number can be kept in advantageous locations.



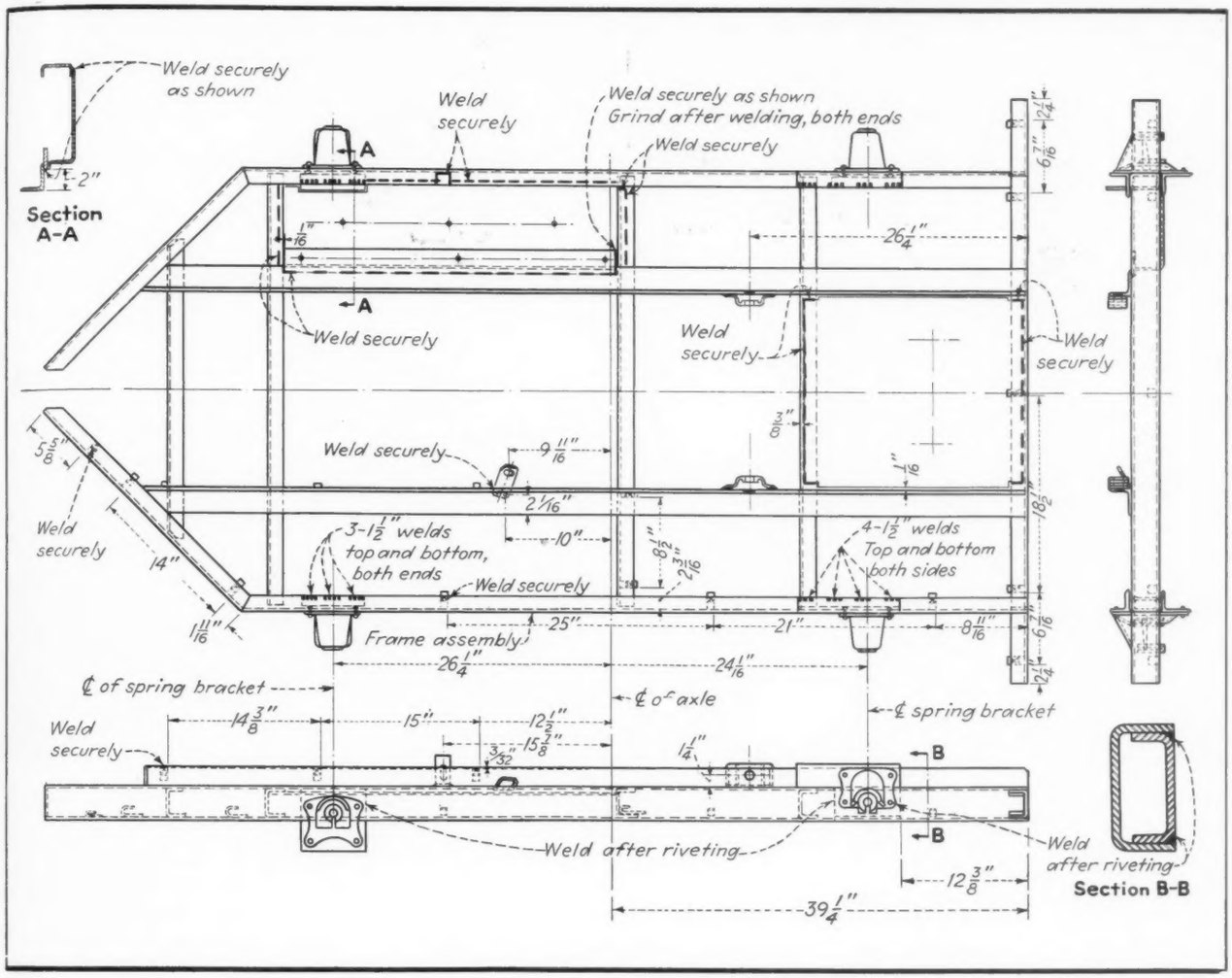


FIRE PUMP
¾ VIEW — SKID MODEL

Apparatus includes a Chrysler T-118 industrial engine having an automotive rating of 120 hp., which drives a centrifugal pump designed by the Hale Pump Company. Two sections of suction hose and 500 ft. of 2½ in. standard fire hose are generally carried on two double reels. A variety of nozzles to give either a heavy stream or a spray for fighting incendiary bombs is also part of the equipment.

Trailer for carrying the engine and pump assembly has two wheels equipped with standard size pneumatic tires. Adjustable supports are provided front and back. Trailer is of sturdy, light steel construction, when loaded it is balanced within 200 lb. A coupling link is provided for hooking the trailer to the bumper of an automobile.

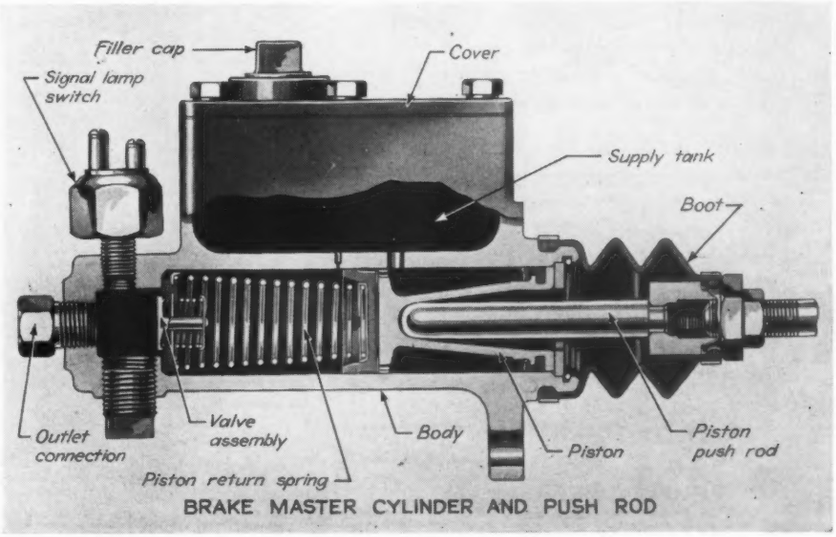
Alternate fire-fighting unit mounted on skids can be carried on any small truck by placing the pumping apparatus in the body close behind the cab and carrying the hose in the middle and rear part of the body in suitable boxes or on reels.



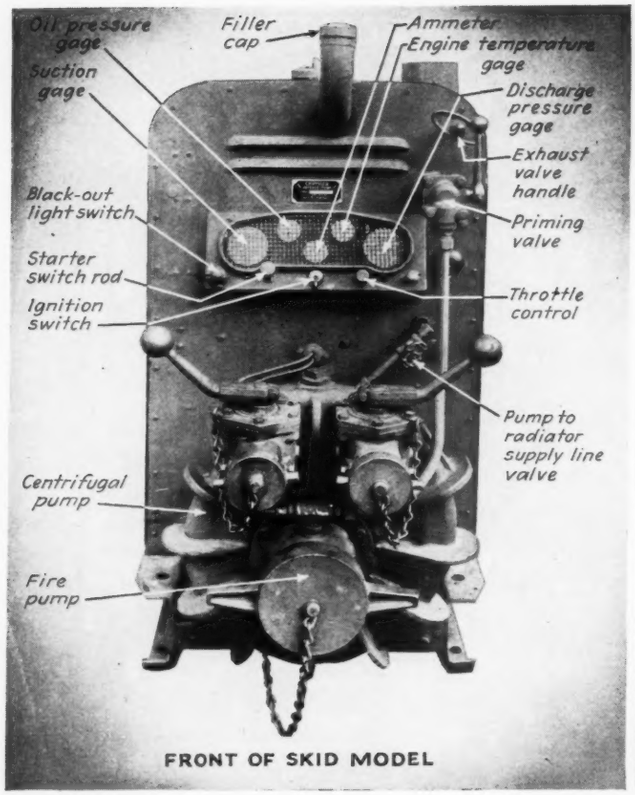
Trailer frame of the War Emergency fire-fighting apparatus is of sturdy construction with four cross-members and two 2x3-in. angle irons welded lengthwise of frame. The frame is supported on semi-elliptic springs attached to the axle, similar in design to those used in automobiles, but without the differential. Chrysler hydraulic brakes are used. Master brake cylinder, assembled to the hitch of the lunette eye at the front end of frame, operates automatically. The construction of the towing connection is such that when pull on the trailer ceases the hitch takes on a downward movement, and actuates a piston rod which applies the hydraulic brakes.

Brake action on the Fire Trailer is automatic; the brakes are applied and released by the position of the coupling. When the trailer is being towed, the coupling is in the full upward position and the brakes are released; as the trailer coasts against the towing car, the weight of the trailer causes a downward movement of the coupling where it is anchored to the trailer frame. The movement of the draw-bar moves the master cylinder piston inward through the linkage attached to the coupling and applies the brakes.

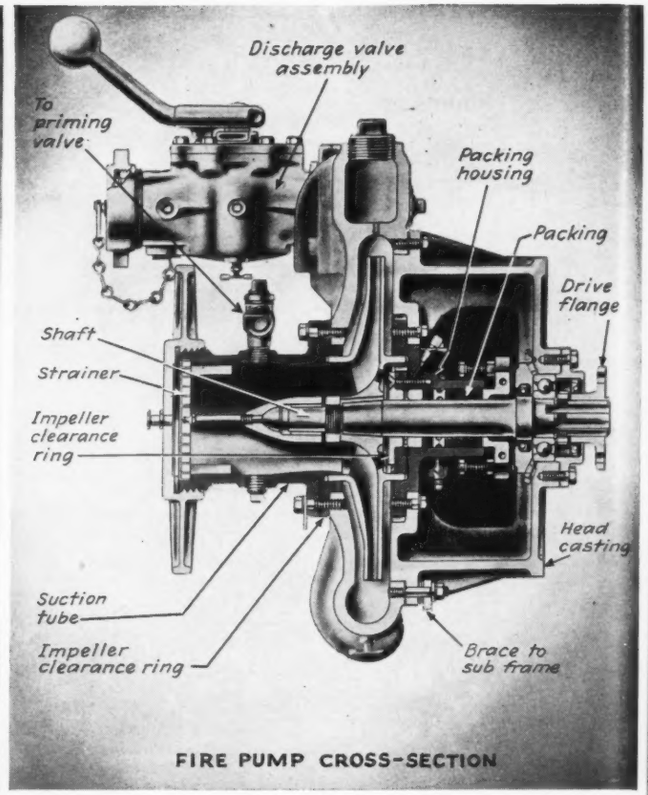
Before starting to reverse the Fire Fighter when attached to a tow-car, a ⅜ in. pin is inserted in holes at extreme front of the frame. Pin then locks the coupling in place thus preventing any downward movement which would apply the brakes when reversing.



BRAKE MASTER CYLINDER AND PUSH ROD



FRONT OF SKID MODEL



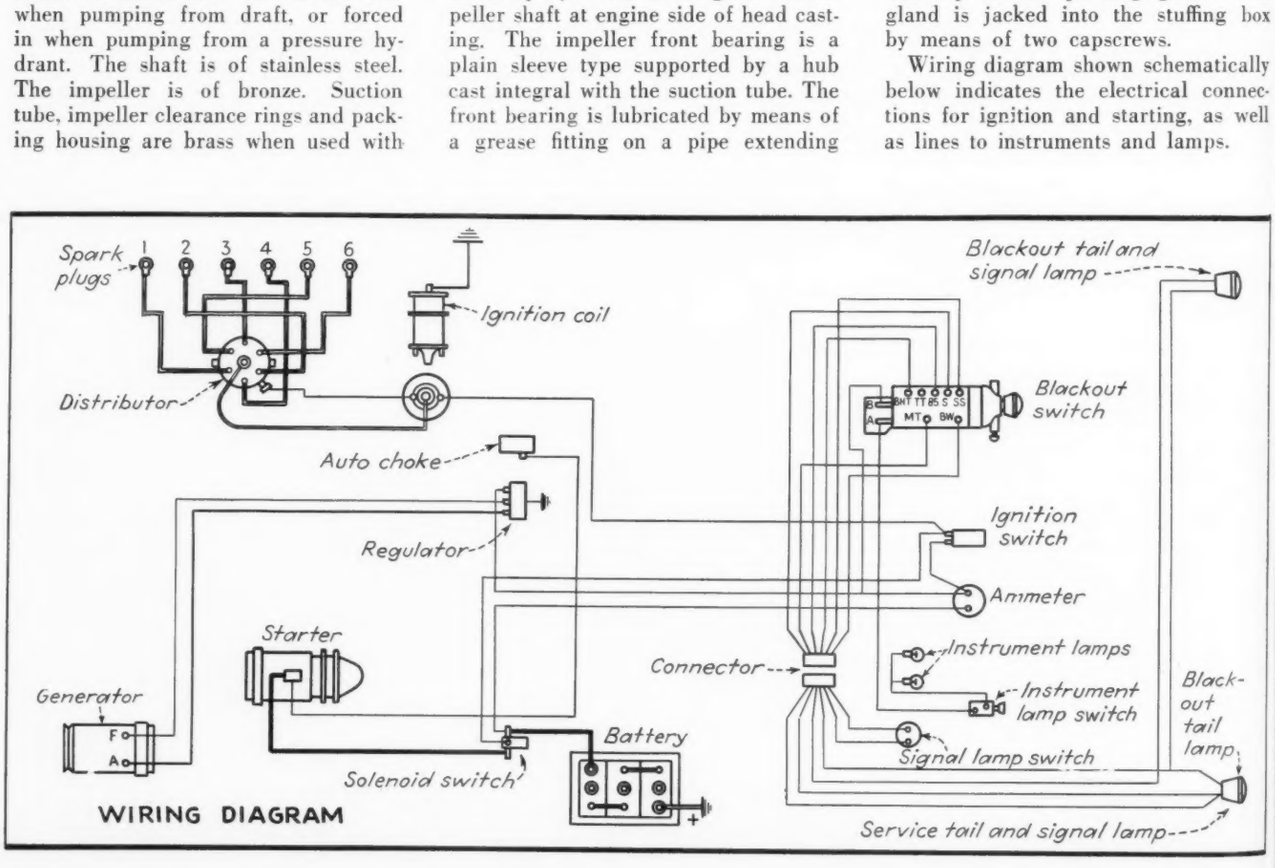
FIRE PUMP CROSS-SECTION

Fire pump has a capacity of 500 g.p.m. at 120 lb. per sq. in. pressure, is of the single stage, centrifugal type. Water is drawn into the suction side when pumping from draft, or forced in when pumping from a pressure hydrant. The shaft is of stainless steel. The impeller is of bronze. Suction tube, impeller clearance rings and packing housing are brass when used with salt water, otherwise they are of malleable iron.

Unbalanced thrust of the impeller is taken up by a ball bearing on the impeller shaft at engine side of head casting. The impeller front bearing is a plain sleeve type supported by a hub cast integral with the suction tube. The front bearing is lubricated by means of a grease fitting on a pipe extending from the hub to the suction strainer.

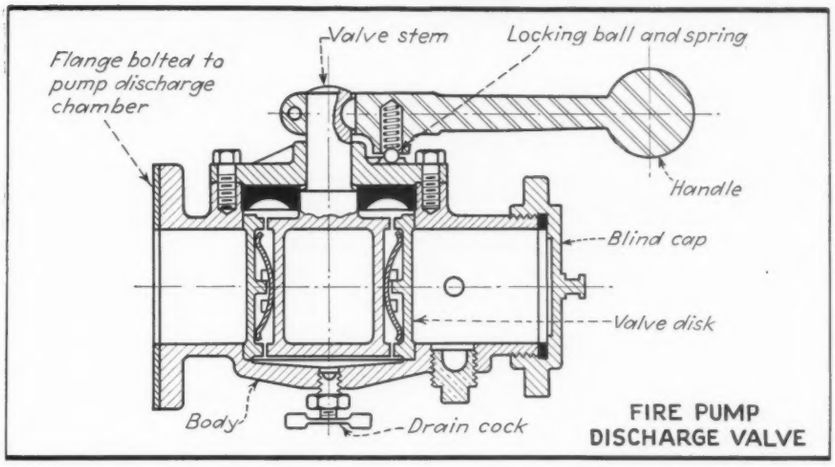
Head casting has openings on the outside through which the operator can take up on the packing gland. The gland is jacked into the stuffing box by means of two capscrews.

Wiring diagram shown schematically below indicates the electrical connections for ignition and starting, as well as lines to instruments and lamps.

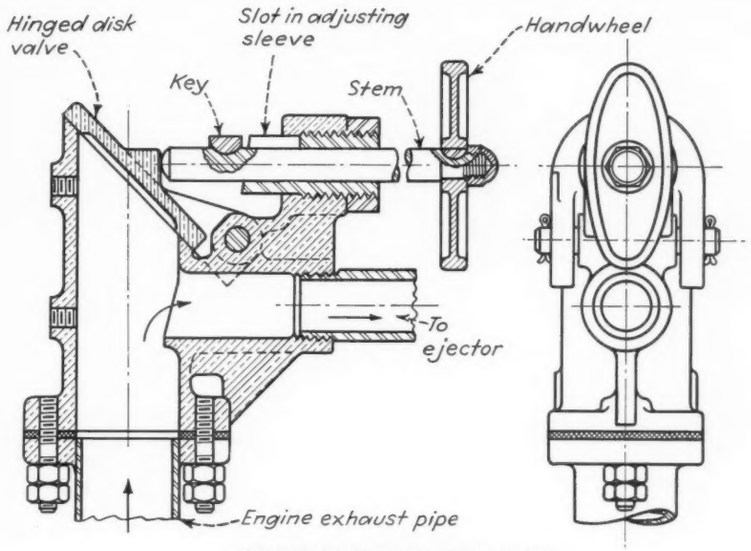


WIRING DIAGRAM

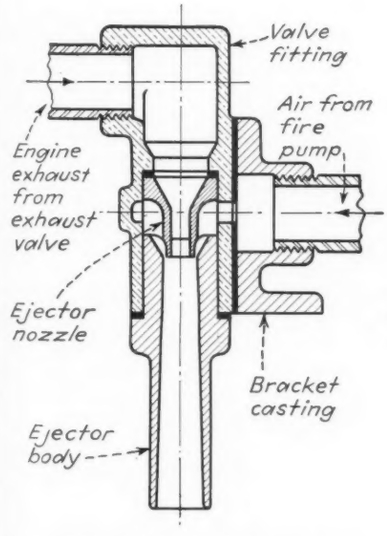
Two discharge valves having integral cast flanges on their intake sides are bolted to the discharge chamber at the top of the pump body casting, one on each side of the vertical center line. These valves open and close the pressure side of the pump to the connected hose lines. Valve bodies have male threads to receive standard hose couplings. The valve control handles are provided with spring and ball latch assemblies for locking the handles in either the open or shut positions. Each valve body is tapped under the plug valve to receive a drain cock. Valve disks are brass. Valve caps are brass castings. Valve stems are machined from steel forgings.



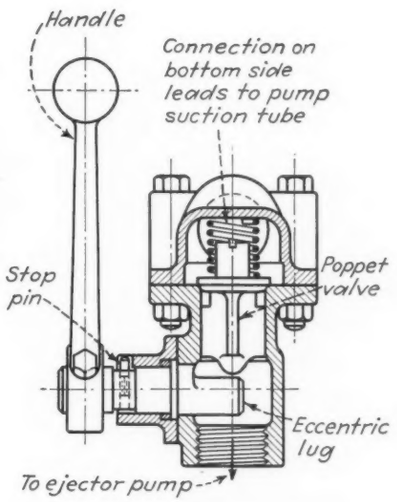
FIRE PUMP DISCHARGE VALVE



ENGINE EXHAUST VALVE



PUMP EJECTOR PRIMER



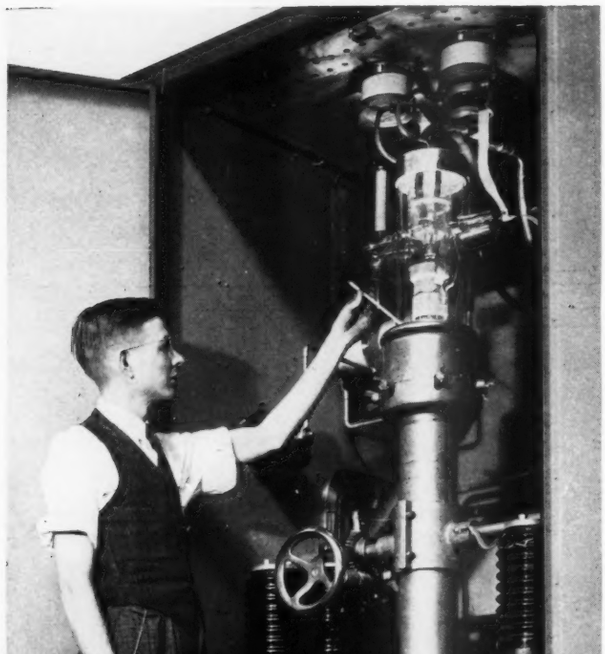
PRIMING VALVE

Valve placed in the engine exhaust pipe when open permits direct exhaust of the engine. When this valve is closed, the exhaust is directed through an ejector to prime the pump. Valve disk which swings on a pin in the body is held closed by a twisting motion of stem and hand wheel, a pin in the stem riding on the angled face of the adjusting sleeve causes the locking action. To open the valve, the stem is turned through approximately 180 deg., then pulled out; a slot in the adjusting sleeve being provided to receive the stem key. The valve is then forced open by the pressure of the exhaust from the engine. Exhaust valve handle is at top left hand side control panel.

Ejector primer assembly is mounted on inside of control panel, and is connected by piping to the engine exhaust valve and the pump priming valve. When the engine is running and the exhaust valve is closed, exhaust from the engine flows into the top chamber of the ejector and is deflected downward through a nozzle which has an opening to increase the velocity of the exhaust gases, thus creating a zone of partial vacuum which draws the air from pump, and sucks water into the impeller chamber to prime the pump.

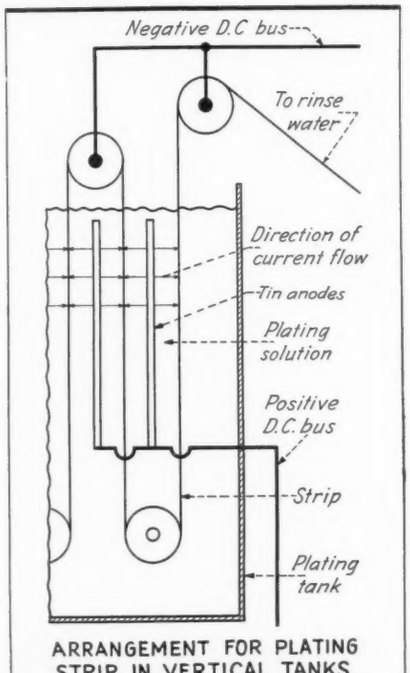
Pump priming valve is connected by piping between a tee on the top side of the pump suction tube and the ejector primer. To put in position for priming, the handle is turned down which causes an eccentric lug on the shaft to push the poppet valve off its seat into an open position. After the pump is primed the handle is turned up (as shown in the illustration), this movement retracts the eccentric lug and permits either the spring or water pressure to seat the poppet valve. Priming valve is at the top right-hand side of panel near handle of exhaust valve.

INDUCTION HEATING HELPS CONSERVE CRITICAL TIN



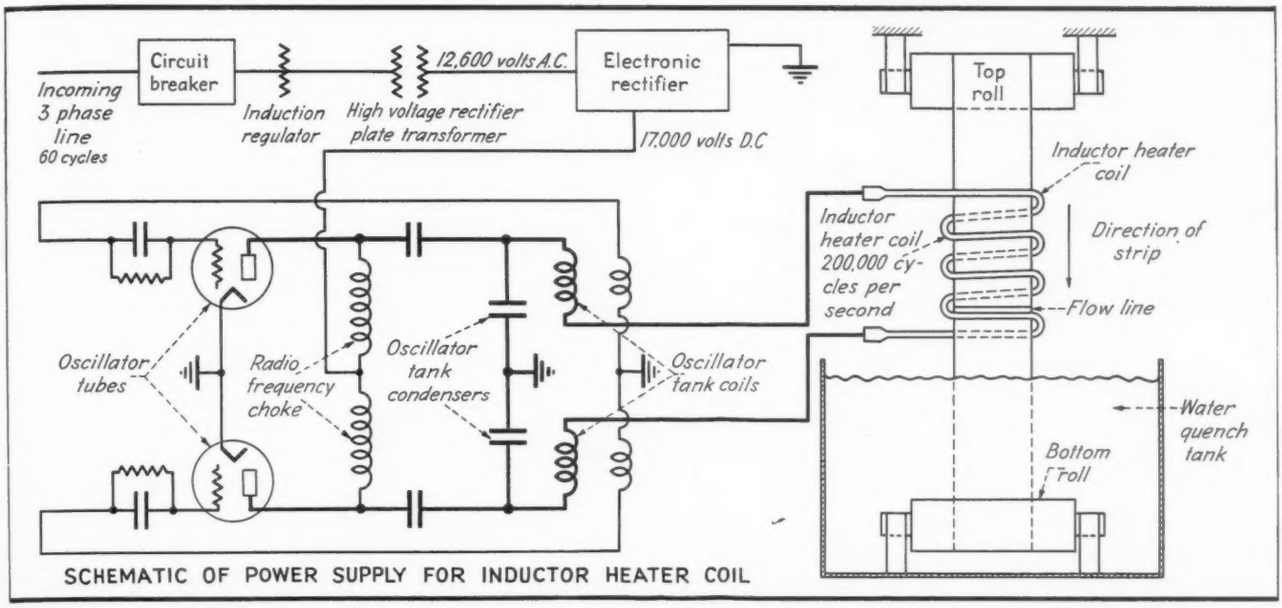
Accelerated by the shortage of tin, and by the urgent need to protect rations for the nation's armed forces as well as by the necessity of meeting their rapidly growing requirements, development of processing lines for the electrolytic disposition of tin on steel have passed from the laboratory stage to a perfected industrial process. Tinning lines in the near future will turn out a sheet, tinned on both sides, three feet wide, at the rate of 1,000 ft. per min. Tin plate made by the old process in which steel sheets are dipped into molten tin ordinarily takes one and one-half pounds of tin for every 100 lb. of steel. The electrolytic tinning method requires only one-half pound of tin for every 100 lb. of steel. In the electrolytic process the strip can be handled in large coils and the coating is applied uniformly. Because the tinplate produced with electrolytic process has a gray matte surface it is necessary to reflow the tin coating to obtain a smooth, polished surface. This flowing not only improves the appearance, it also reduces the porosity of the coating and improves resistance to corrosion. Mr. Glenn E. Stoltz, a Westinghouse engineer, conceived the idea of using radio waves to heat the tin coating to a point where it would flow evenly over the steel foundation. The Westinghouse Electric & Manufacturing Company through its engineers have designed and built the electrical drives and apparatus for several installations.

High frequency power for the tin flowing operation is supplied by huge 100 kw. vacuum oscillator tubes. 60 cycle alternating current is rectified to direct current at 17,000 volts and fed to the plates of oscillator tubes where the current is converted to 200,000 cycles per sec. and then sent out through an inductor coil where radio waves are passed around the plated metal strip travelling through the coil. The waves set up counter currents near the metal surface which generate heat that melts down and fuses the tin coating. In the induction system there is no contact between the coated strip and any stationary or rotating member while the tin is being flowed. Thus, there can be no marking of the strip either by electrical or mechanical action during the operation. The heating of the strip is done in a short working zone even at high speeds. The space required being about 10 to 12 ft. at a speed of 1,000 ft. per min. All the heating required to flow the tin is done before the strip enters the quenching tank.



ARRANGEMENT FOR PLATING STRIP IN VERTICAL TANKS

Tin is plated on steel strip in tanks containing an electrolytic solution in which are submerged tin anodes connected to the positive side of a d.c. bus. The negative bus is connected to the steel strip by means of copper rolls and collector rings. The 2,500 amperes of current required per anode is supplied by a motor-generator set. As the current flows from the positive to the negative bus bars the tin leaves the anode in ion form and deposits on the moving strip. In a vertical tank electroplating line as shown here, about 30 millionths of an inch of tin plate is deposited on each side of the strip. In a horizontal tank electroplating line, like that shown on the next page, the two sides of the sheet are tinned separately allowing variation in thickness and even in kind of metal deposited, if desired. The thickness of the tin deposited or coating weight is a function of both time and speed of travel. Hence, the plating power required is determined by the speed of the line at which a given coating weight is to be applied.

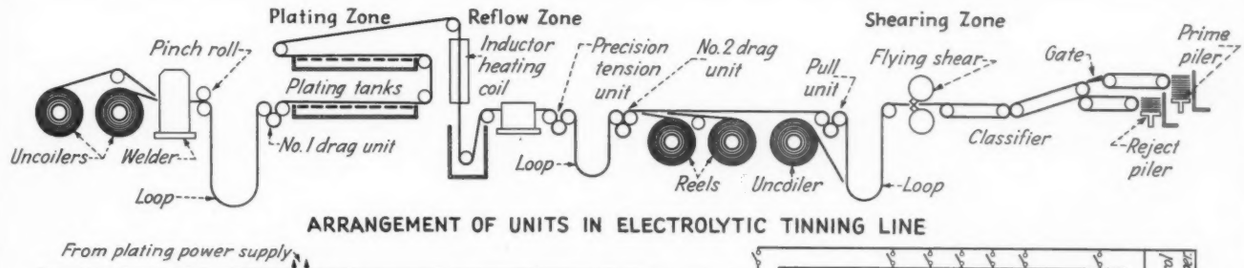


SCHEMATIC OF POWER SUPPLY FOR INDUCTOR HEATER COIL

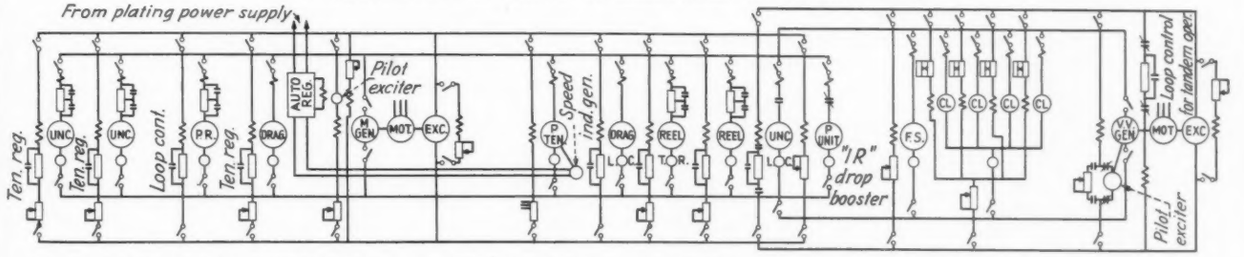
Alternating current from the supply lines is converted to d.c. power by a high voltage rectifier plate transformer and an electronic rectifier. The d.c. power, applied to the plates of a bank of vacuum tube oscillators totalling 3,600 kw. capacity, and similar to those used with radio broadcasting transmitters, is converted into high frequency a.c. power of 200,000 cycles per sec. The natural or resonant frequency of this power is determined by the timed circuit consisting of an oscillator tank coil and the tank condenser. Water cooled copper tubes conduct this high-frequency power to the inductor heater coil, installed in the line following the plating tanks.

Electrolytically plated strip, dried by hot air, enters the inductor heater coil at 130 deg. F. High-frequency current in the inductor heater coil sets up lines of flux. The direction of these lines reverses 400,000 times per sec. Eddy currents are induced in the strip as it passes through this rapidly changing magnetic field and cuts the lines of flux. Heat is produced by the resistance of the strip to the flow of these induced eddy currents. The heating is proportional to the square of the current times the resistance of the current path. When the heat caused by the induced eddy currents raises the temperature of the tin to the fusion point, 452 deg. F., the granular deposit on the steel sheet flows into a smooth, shiny surface. The strip then runs through a water quenching tank where the tin is hardened and cooled to about 100 deg. F. temperature.

From the quenching tank, the strip is fed to either coilers or shears.



ARRANGEMENT OF UNITS IN ELECTROLYTIC TINNING LINE

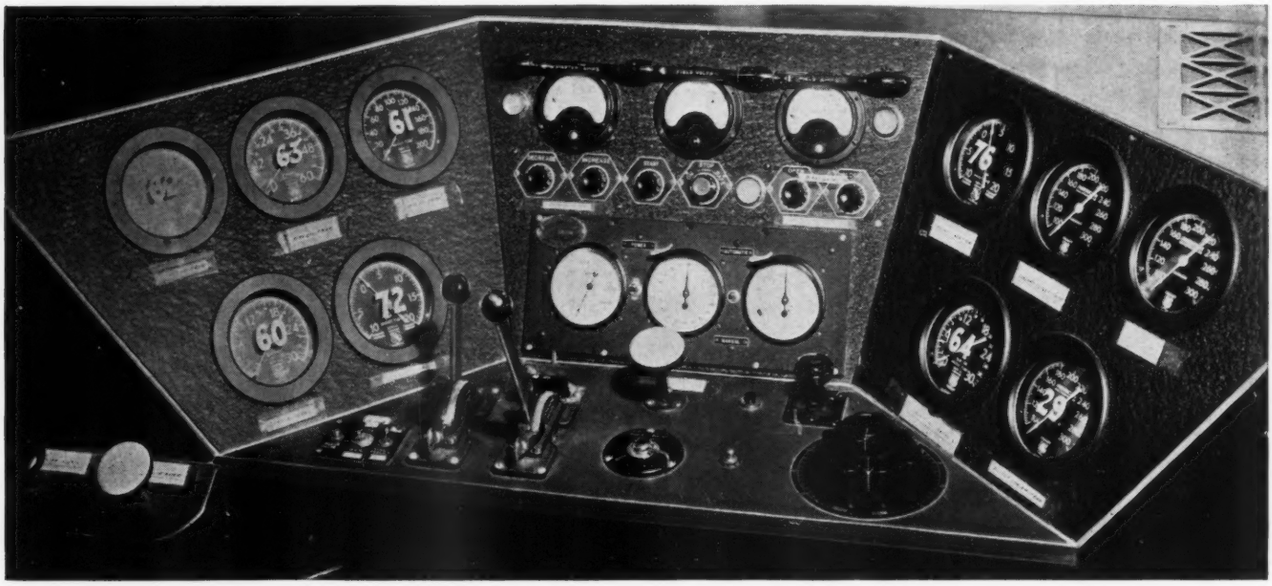


ELECTRICAL CONTROL DIAGRAM FOR ELECTROLYTIC TINNING LINE VARIABLE-SPEED HORIZONTAL TANK LINE

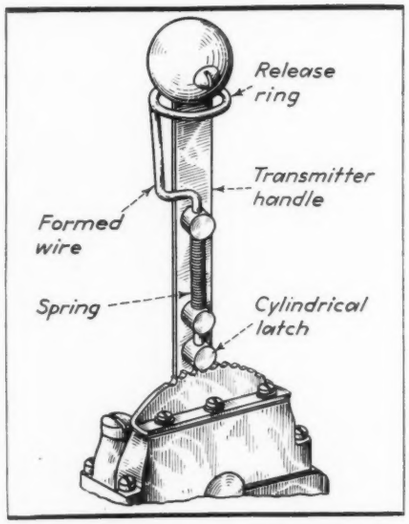
Variable-speed, horizontal tank line shown schematically above with circuit diagram of electrical control, uses about 25 d.c. motors of from one to 125 hp., and 75 a.c. motors from one-half to 60 hp. The plating unit takes about 60,000 amp. at 12 volts. The various drives must operate in synchronism at both normal running speed and at a much lower threading speed. All driving motors, therefore, have a flat speed characteristic over the entire operating range. As the slowest speed may be at a generator voltage lower than the internal resistance drop of some of the motors, it is necessary to use "IR" drop boosters in the line to prevent any tendency to stall.

AIRCRAFT ENGINES REMOTE-CONTROLLED BY HYDRAULICS

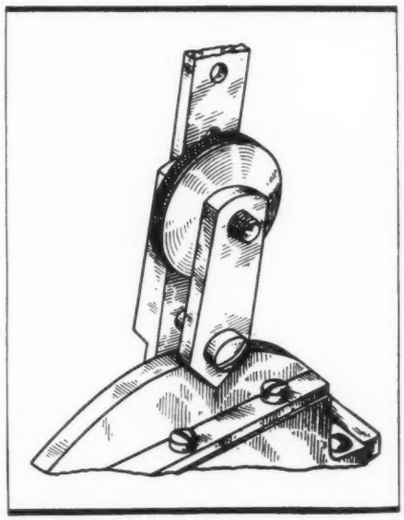
Designers of this simple Exactor (Sperry Products, Inc.) hydraulic remote control aimed at a system with no creep, lost motion, or resilience so that the position of the lever on the receiver unit could be accurately controlled by the handle on the transmitter. These were requirements in applications to which the Exactor control is now put —such as the throttle, mixture and airscrew controls in the Short Stirling bomber, firing gear in motor torpedo boats, and the units shown below mounted on the Packard-Rolls-Royce test control board. These design problems were met by accurately balancing the springs and lever arms of the units, by careful design of seals to prevent leakage of the hydraulic medium, and by a unique synchronizing valve.



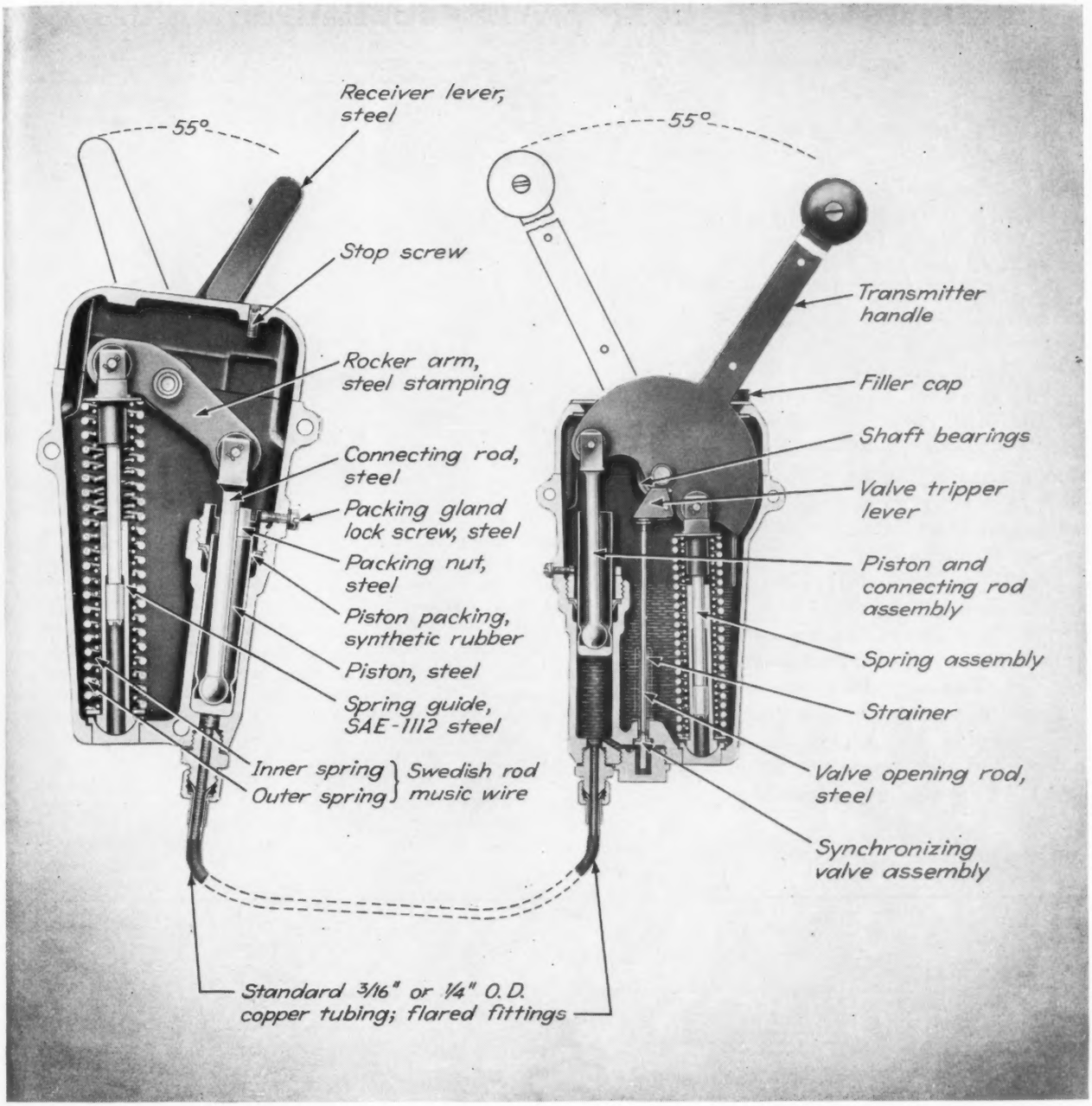
Housings for transmitter (above) and receiver are die-cast or sand-cast aluminum or sand-cast bronze. Aluminum is used for light weight in aircraft and bronze is used for industrial and marine applications where corrosion resistance, casting properties and machinability are required.



Latching device is available for locking the handle of the transmitter in the desired fixed position. Device, weighing only 4.5 oz., can be easily attached. It permits locking the handle at either end of travel and at intermediate positions not less than 5 deg. apart on the quadrant.



Friction brake can also be applied to standard transmitter to lock the handle in any desired position in special applications where device controlled is pre-loaded. This eliminates creep caused by preload or by vibration. Design is simple, brake being tightened by a knurled nut.

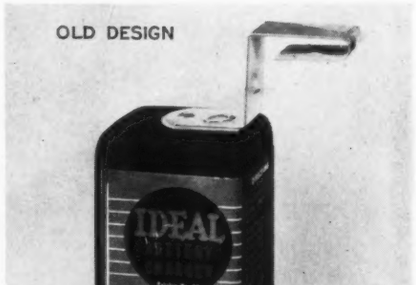


When handle of transmitter is advanced, piston forces oil through single tube to receiver, moving the receiver piston upward and causing control lever to move through an arc equal to that of transmitter handle. When transmitter handle is returned, fluid is forced from receiver into transmitter by spring pressure. Springs in transmitter and receiver are balanced against each other at all positions. As a spring increases in length, the force it exerts decreases. To compensate for this, the arms are designed so that their effective leverage increases as the springs lengthen. Springs are concentric because a single spring could not be designed with safe working stresses in the space available. To prevent inaccuracy in event of oil leakage or temperature changes, a synchronizing valve is placed between the cylinder and reservoir in the transmitter. By pulling the handle hard against its spring, this valve is opened and the pistons are synchronized at the starting point.

Outstanding materials selection problem was to obtain a cylinder packing with low leakage rate, low friction, good resistance to hydraulic fluid and not susceptible to sudden failure. After extensive research and trial, a synthetic rubber compound was selected. Top seal gasket permits transmitter to function upside down for limited time. To simplify production problems, the following parts are identical for transmitter and receiver: spring seats, spring assemblies, piston assemblies, clevis bearings, shaft bearings, packings, packing nuts and packing retainers. The receiver can be mounted in any position, but should be close to the mechanism being controlled to avoid long control rod. The receiver lever and actuated arm should be in the same plane so weight of control rod will not place thrust on the receiver lever. For safety, the receiver should be mounted in a position such that because of the action of the load the controlled device will shut off or lock rather than speed up or release in case of hydraulic line failure.

REDESIGNED CHARGER SAVES CRITICAL MATERIAL

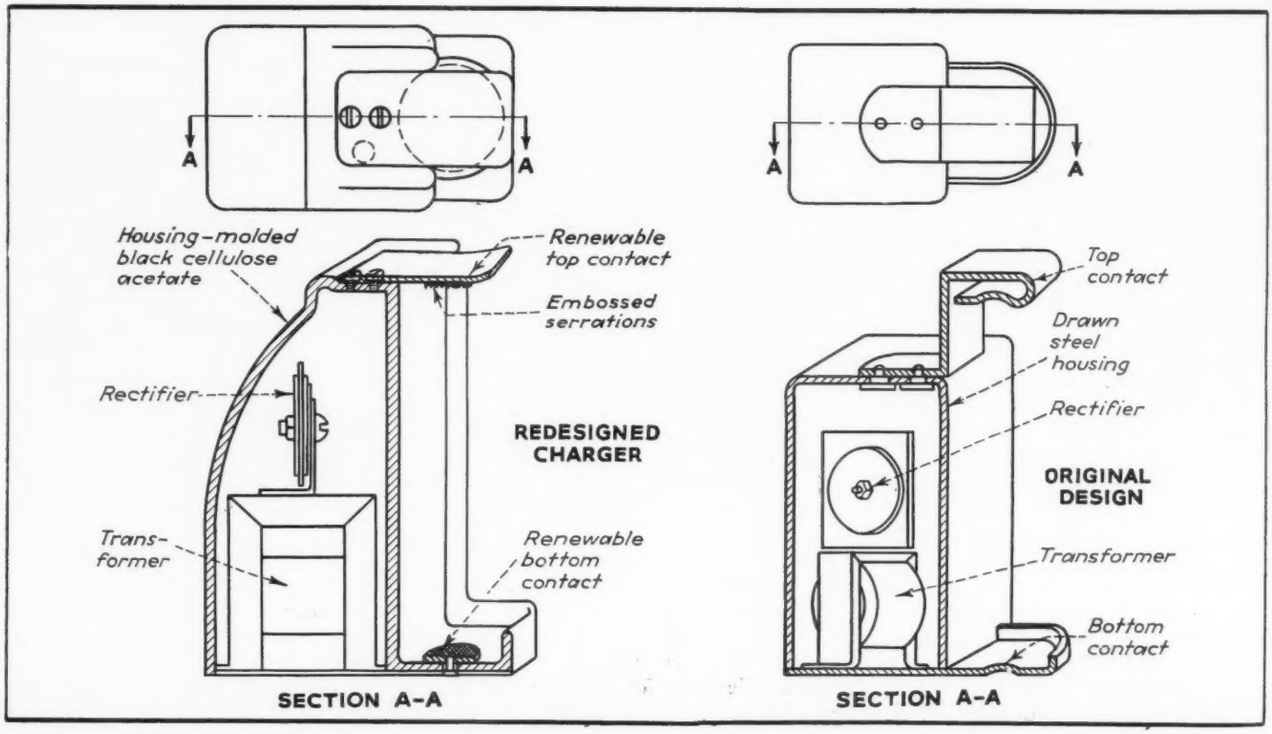
Charger for charging wet cell type storage batteries for flash-lights is redesigned to save critical material formerly used to make the housing and contact elements. Critical materials used in the construction of dry batteries, which when exhausted are scrapped, can also be conserved with the use of the new wet cell batteries which can be recharged over and over again. An interesting feature of the Ideal Commutator Dresser Company's wet cell is a battery case made of transparent Lucite. The wet cell used in flash-lights is 1¼ in. dia. by 4¾ in. high, it replaces two 1¼ in. size D dry cells. The charger consists of a transformer and rectifier plates inclosed in a housing, with contact elements at top and bottom to receive the battery. A two conductor cord set connects the charger to the electrical service.



Redesigned charger has a housing molded of a black cellulose acetate. When going to plastics the designer availed himself of the opportunity afforded to use curved contours thus improving the appearance of the charger. In the new design the contacts or electrodes are renewable. The top contact, fastened to the housing with two screws, is made from 1⅛ in. strip about 2⅜ in. long; it is flat except for a slight curl at the outer edge. Small serrations are embossed in the piece to improve contact. Bottom contact is a knurled disk connected to the metal base with a countersunk screw. Construction is rugged, as well as weather and moisture proof.

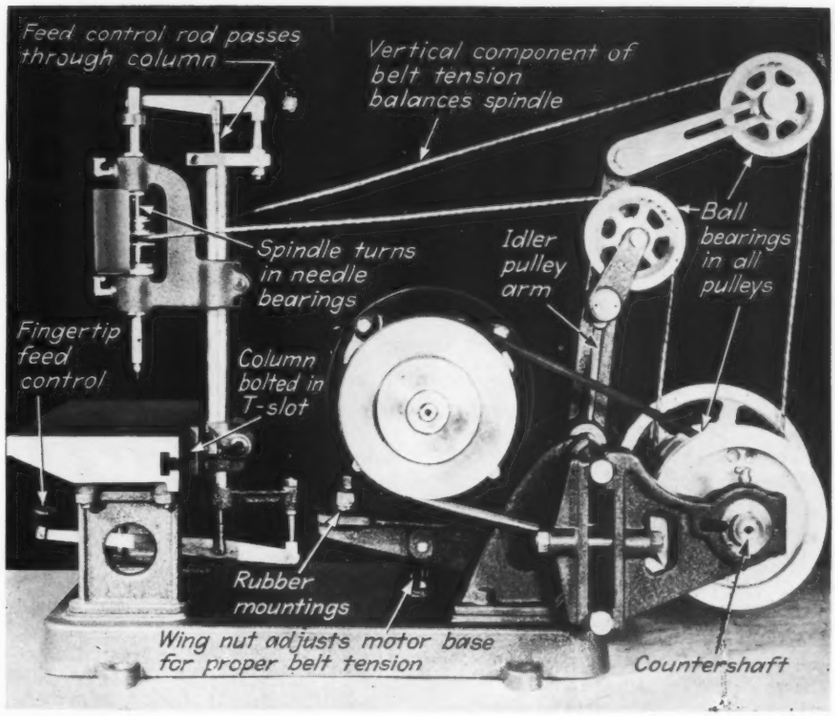
Housing in original design was blanked, cupped and drawn to shape from 26 gage steel, then painted with a black wrinkle finish. Top contact element, riveted to housing, was formed from 1 in. strip stock about 5 in. long. Bottom contact element was a stamping with front end flanged up to receive battery. Stamping also served as a base upon which to mount the transformer.

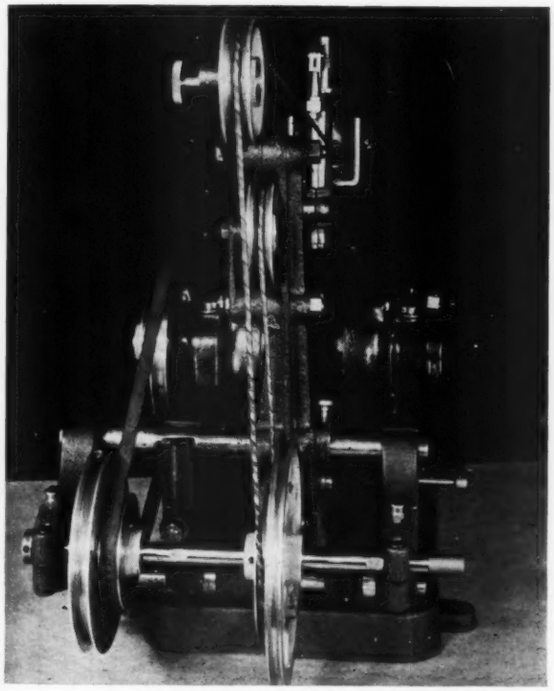
Cross-sections of redesigned and of original chargers are shown below.



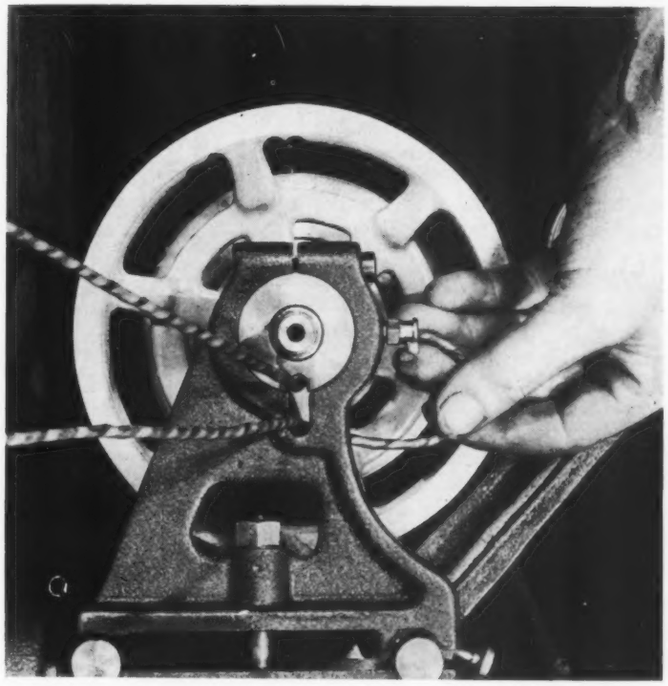
BELT TENSION BALANCES DRILL SPINDLE

Sensitivity in the new super sensitive drill press of Edward Blake Company is achieved by accurately balancing the weight of the spindle against the vertical component of belt tension. This balance, plus convenient sensitive fingertip control, special design features to eliminate vibration, and eight speeds from 3,000 to 23,000 r.p.m., permit accurate work with drills from 0.004 to 1/16 in. dia. Precision spindle is hardened, ground and lapped, and accurately balanced. Needle bearings which permit spindle to "float" vertically in drilling head are completely inclosed. Head is mounted on hardened and ground column and is adjustable radially and vertically. Feed control lever is linked to top of spindle through the spindle mount; weight of feed mechanism is counterbalanced by a long spring within the mount. Column is attached to work table by bolts in T-slot. Frame castings are wrinkle-finished. Motor, 110-volt, 1/6 hp., running at 1,750 r.p.m., is mounted in rubber resilient bushings to absorb vibrations.


Feed control rod passes through column
Vertical component of belt tension balances spindle
Ball bearings in all pulleys
Spindle turns in needle bearings
Idler pulley arm
Fingertip feed control
Column bolted in T-slot
Rubber mountings
Wing nut adjusts motor base for proper belt tension
Countershaft



Eight speed changes are achieved by changing V-belt on motor and by changing spindle drive belt on the countershaft and spindle. Countershaft and all idler pulleys are perfectly balanced and mounted in ball bearings. Spindle drive belt tension is adjustable by cam on pivot shaft of idler arm. V-belt pulley tension is adjusted by bolt and wing-nut which raises or lowers the pivoted motor base. Belt may be changed by lifting the motor with lever-actuated cam.



Unique design detail permits replacing belt without dismantling the countershaft. First, the belt is pushed through the hole as shown. By loosening the binder screw, the bearing can be turned one full revolution with one side of the belt in the bearing slot. This motion loops the belt around the countershaft. The rest of the belt is then drawn through the hole, the screw is tightened, and the belt placed over the pulleys. An endless belt is specified in order to obtain the vibrationless operation that is necessary for machining fine precision work.

Magnet Coil Life As Affected By Higher Operating Temperatures

GRAHAM LEE MOSES
Coil and Insulation Engineer
Westinghouse Electric & Manufacturing Company

Service life of magnet coils is a function of operating temperature which in turn is determined by voltage, wire size, winding space, duty cycle and similar factors. From this data, a fair estimate can be made of normal life expectancy of coils designed smaller.

INCREASING scarcity of materials has accelerated the trend toward designing magnet coils to operate at higher temperatures in order to conserve critical materials or save weight and space. Because a higher operating temperature accelerates aging of all organic insulating materials, such as used on Class A magnet coils, the coil should not be designed or applied to operate at an increased temperature without a full knowledge of the sacrifice in life which may result. The following information has been compiled covering the relation of operating temperature and life to the design and application of Class A insulated magnet coils, this being the classification into which most magnet coils fall. Magnet coils that use Class B insulation involve many special factors which require such coils to be considered as a separate subject.

Life of electrical apparatus must be recognized as a variable quantity which cannot be estimated accurately, but whose order of magnitude can be approximated. It appears probable that operating temperature is the most important single factor in the life of Class A insulation and, therefore, a significant factor in determining overall coil life. Thermal aging of insulation is important in determining when vibration or expansion and contraction may become effective in producing mechanical failure. Thermal aging also renders insulation porous and opens the way for moisture absorption as a cause of failure. Thus it is apparent that thermal aging prepares the way for other factors to produce failure.

It is widely recognized that the life of Class A insulation is a logarithmic function approximating on "8 deg. C. law." Under this conception of insulation life, a change in operating temperature of 8 deg. C. produces a change in life expectancy in the ratio of 2 to 1, with life varying inversely as the temperature. The effect of operating temperature on magnet coil life under this law is illustrated in Fig. 1. This is based on 100 percent life at the maximum permissible operating temperature under A.I.E.E. rules, namely, 85 deg. C. rise above a 40 deg. C. ambient or 125 deg. C. total temperature as determined by measurement of the resistance of the winding, the temperature rise above the ambient temperature being caused entirely by the RI^2 loss in the coil.

The continuous or root mean square voltage that is applied to a magnet coil is an important factor in determining its life because of the tremendous effect of voltage on operating temperature. The temperature rise of a magnet coil varies approximately as the square of the RMS or root mean square voltage except for the increase in coil resistance with temperature. The effect of RMS voltage on temperature rise for a shunt d.c. coil without external resistance is shown by the curve in Fig. 2. The direct effect of the RMS operating voltage on life as determined by operating temperature is illustrated by the curve in Fig. 3 which was calculated from Fig. 1 and Fig. 2. Since most magnet coils are not operated continuously at a constant voltage, the duty cycle in which they actually operate is an important

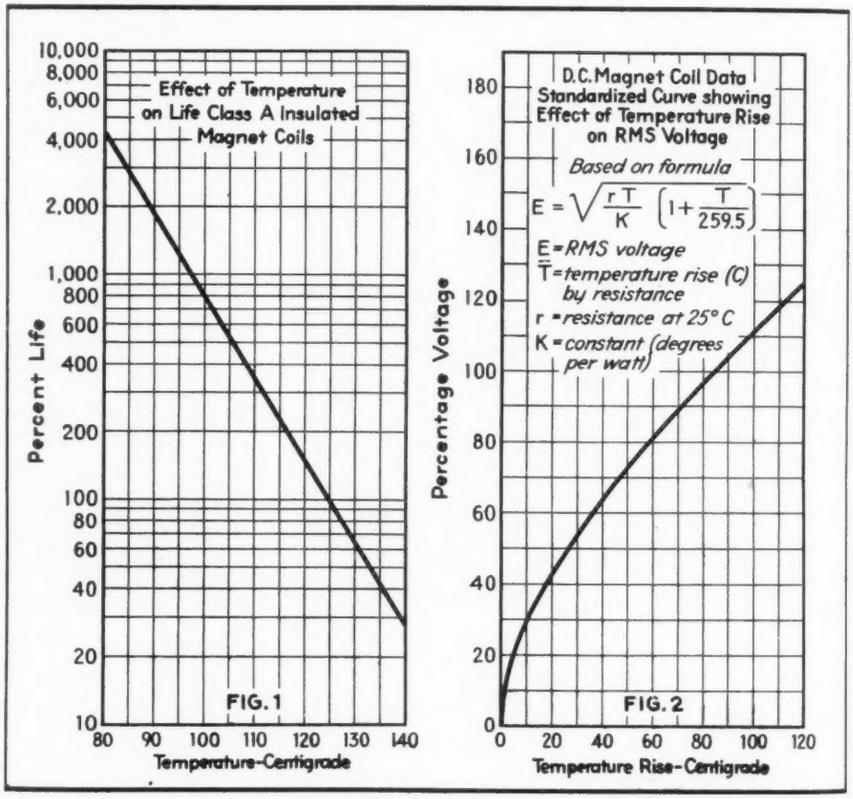


Fig. 1—Effect of operating temperature on relative life of Class A insulated magnet coils.
Fig. 2—Temperature rise of shunt magnet coil as determined by RMS voltage

factor where such coils are operated in intermittent service. The curve in Fig. 4 correlates the effect of duty cycle in percentage "time energized" in relation to life for a magnet coil designed to have its intermittent voltage applied for 38 percent of the time. From this it can be seen that the effect of an error in estimating duty cycle or a change in operating conditions can greatly affect the useful life of a magnet coil.

Effects of Winding Space

Compact, light-weight apparatus is greatly to be desired. However, it should not be obtained at a sacrifice of life below the normal requirements of the service for which the coil is designed. The winding space available for a magnet coil, through its effect on operating temperature, has a considerable effect on life as illustrated by the curve in Fig. 5. This assumes a constant RMS voltage and fixed ampere-turn requirements and varies the length of winding space with a constant winding wall height and mean length of turn. Increases in length are doubly effective in that the power required per ampere-turn is decreased at the same time that the heat dissipating area is increased. Both tend to reduce the operating temperature and increase the life. Therefore, conversely a slight reduction in winding space may produce as illustrated in Fig. 5, a great reduction in life.

The size of wire selected for a specific coil design is important in determining the operating temperature and, therefore, the life. It also determines the ampere-turns produced by the coil when operated at a specific voltage. Assuming that a wire size can be selected which will produce the desired ampere turns, when the coil is hot, at the rated voltage with 85 deg. C. rise, the following set forth the effect upon operating characteristics and life when the coil is wound with the next size larger or smaller wires.

(a) Coil with one size smaller wire will have an RMS voltage rating of 126 percent of the voltage of the original design and will operate at 59 deg. C. rise instead of 85 deg. C. when subjected to the same voltage. The lower temperature and resultant reduced change in resistance will result in the net ampere-turns being reduced only to 85.9 percent instead of to 79.4 percent such as would be obtained at the same temperature, but the life will be increased to 900 percent in relation to the original design.

(b) Coil with one size larger wire will have an RMS voltage of 79.4 percent of the voltage of the original design. It will operate at 121 deg. C. rise instead of 85 deg. C. operated at the same voltage. The higher temperature and greater change in resistance due to operating temperature will result in the net ampere-turns being increased only to 114 percent of the original design instead of 126 percent such as would be obtained at the same operating temperature, but the life will be decreased to 11 percent.

Importance of Temperature

From the foregoing data it can be seen that temperature is an important factor of life of magnet coils using Class A insulation. Since changes in voltage duty cycle and winding space all vitally affect temperature they are also important factors in establishing the normal life expectancy of such coils. It is of great importance, therefore, to evaluate carefully all of these factors in the design and application of magnet coils. Where it is desired to take advantage of increased operating temperature to reduce size and weight of apparatus or to change voltage or duty cycle the change in life expectancy should be carefully evaluated in relation to the life requirements for the intended service.

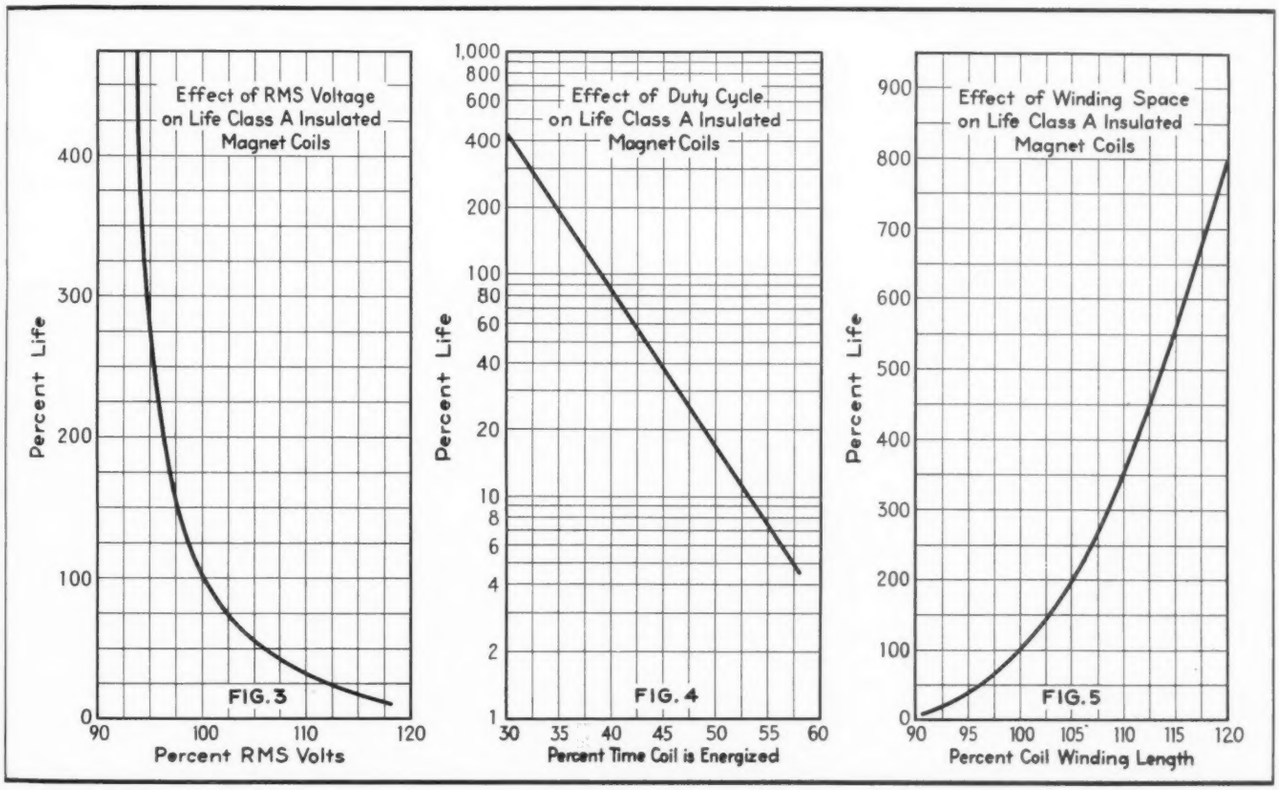
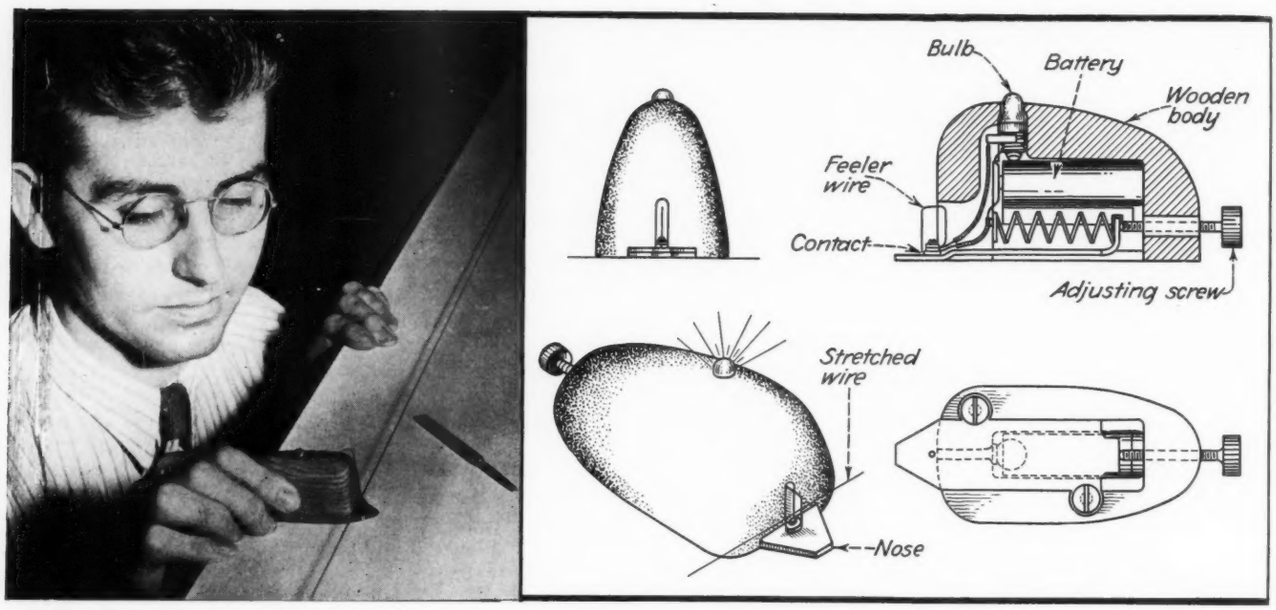


Fig. 3—Effect of RMS voltage on life of class A insulated magnet coils. Fig. 4—Effect of duty cycle on life of class A insulated magnet coils. Fig. 5—Winding space as a factor of life of class A insulated coils



Demonstration of "lofting mouse" for laying out long straight lines by its inventor, J. E. Entrikin, and details of construction

Lofting Mouse Saves Time In Drawing Straight Lines

STRAIGHT LINES longer than are obtainable by a single straight edge are easier to produce as a result of the development of a simple electrical contacting device. It replaces the square and magnifying glass, used in conjunction with the conventional music wire, which is held under tension just above the drawing surface of the lofting platform. Since the device resembles a crouching mouse, it goes by that name.

In the usual method of laying down such a line, a square or steel block is moved into contact with the wire, the point of contact being observed through a magnifying glass. At the point of contact a pencil mark is made on the loft surface. A series of such points are then connected by a straight edge. The inherent inaccuracies of this method, due to the human element involved, often require that the line be checked and rechecked as many as five or six times. The method is tedious and a time consumer.

Details of the Fleetwings mouse construction, which are shown in the accompanying drawings, illustrate its operation. To use the mouse, its thin, whisker-like feeler wire is brought close to the stretched music wire, the mouse being approximately perpendicular to the wire. The adjusting screw is then turned until the feeler wire is deflected by the wire and makes an electrical contact, thus closing a battery circuit through the lamp bulb on the mouse's back. The adjusting screw is then backed off until the light is extinguished and the music wire is not deflected by the feeler wire. A mark is made along the nose of the mouse. The process is repeated along the wire as many times as necessary and the series of points are connected by a straight edge.

Repeated use of the mouse in the Fleetwings loft has proved that it is much faster, more accurate, and easier to use than the conventional method. Several man-hours are saved each time the new short-cut method is used.

The normal use of the mouse is in laying a reference or base line when work is first started. It can also be used to advantage in establishing a line between any two known points. When used in this manner a mouse is placed on each of the two points between which the music wire is to be rigged. The wire is then stretched across the surface of the loft floor and adjusted by operators at each end until it contacts the feeler of each mouse, as indicated above. The wire is then clamped.

Conventional method of laying out long straight lines is tedious

Torsion Analysis of Open Shell Structures — II

E. H. SPAULDING
Structures Engineer, Lockheed Aircraft Corporation

An application of the mathematical analysis of the stress distribution in the shell structures discussed in Part I to an illustrative example, with data obtained from an experimental structure that was subjected to a stress distribution test. Theoretical calculations and test results are listed and compared.

TO ILLUSTRATE the procedure of applying the theory discussed and the equations derived in Part I of this article, which was presented in the December 1942 issue of PRODUCT ENGINEERING, the stress distribution within the structure shown in Figs. 13 and 14, when an external torsion of 23,100 in. lb. is acting, will be determined.

As an aid to the solution of this problem tabular forms are presented. It is assumed that the skin is unbuckled and fully effective in bending. This is assumed for convenience here, but effective widths of skin should be found when applying this analysis to a practical problem. The slide rule is not sufficiently accurate in the solution of these section properties, because the position of the shear center is sensitive to small variations. A small error in the shear center position will cause unbalance in later calculations if an equilibrium check is made.

Shear Center Position

Referring to Fig. 13, the shear flow in any panel resulting from a horizontal load, H, acting through the shear center is equal to HQ/I. The moment of this shear flow about the center of the section is equal to

$$M = \Sigma\ (HQ/I)\ 2\ \Delta B$$

The position of the shear center with respect to the center of the circle will be

$$\bar{\bar{y}} = M/H, \text{ or } \bar{\bar{y}} = \frac{2}{I_{yy}} \Sigma\ Q_{yy}\ \Delta\ B \qquad (13)$$

The value of $\Delta\ B$ is constant for this particular section.

$$\text{Shear center} = \frac{2 \times 174.490 \times 29.4}{331.4}$$

$$= 31.0 \text{ in. above center of section}$$

Stress Calculations

It is not necessary to solve Equation (7) when dealing with a symmetrical section such as the one treated here, since it is obvious that stringer No. 10, Fig. 13, is the point of zero stress.

The swept area from the shear center of a circular section can be expressed mathematically. Referring to Fig. 13

$$S = \frac{\bar{\bar{y}}\ R \sin\theta}{2} - \frac{R^2\ \theta}{2}$$

or
$$S = \frac{R}{2}\ (\bar{\bar{y}} \sin\ \theta - R\ \theta) \qquad (14)$$

now
$$\frac{f_c}{K} = S = \frac{R}{2}\ (\bar{\bar{y}} \sin\theta - R\ \theta)$$

Since $R/2$ is a constant, it can be combined with K so that

$$K' = \frac{KR}{2} \qquad (15)$$

From Equation (10)

$$T = K \Sigma \frac{q}{K} 2 \Delta S$$

therefore $23{,}100 = K' (-6.170 \times 15)$

and $K' = -250$

In general, slide rule accuracy is not sufficient for these tables. Columns 4

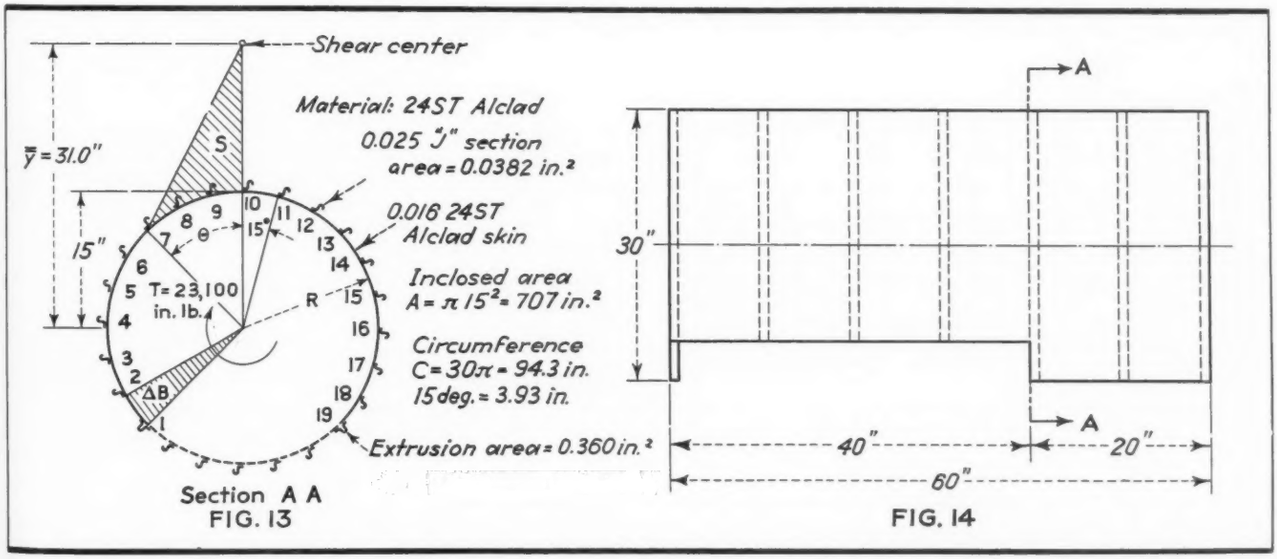


Fig. 13—Section view through A-A of cylinder used in illustrative example. Fig. 14—Side view of cylinder used in illustrative example

Table I—Section Properties

Stringer No.	Areas			x	Ax	$\Sigma Ax = Q_{vv}$	Ax^2
	Stringer	Skin	Total				
1	0.3600	0.0475	0.4075	10.8	4.401	4.401	47.5
2	0.0382	0.0630	0.1012	13.0	1.316	5.717	17.1
3	0.0382	0.0630	0.1012	14.5	1.467	7.184	21.3
4	0.0382	0.0630	0.1012	15.0	1.518	8.702	22.8
5	0.0382	0.0630	0.1012	14.5	1.467	10.169	21.3
6	0.0382	0.0630	0.1012	13.0	1.316	11.485	17.1
7	0.0382	0.0630	0.1012	10.6	1.073	12.558	11.4
8	0.0382	0.0630	0.1012	7.5	0.759	13.317	5.7
9	0.0382	0.0630	0.1012	3.9	0.395	13.712	1.5
10/2	0.0191	0.0315	0.0506	0.0	0.000	—	0.0
			1.2677			87.245	165.7
			2			2	2
		Total area = 2.5354 in.^{2}				Q_{vv} = 174.490	331.4 in.^{4} = I_{vv}

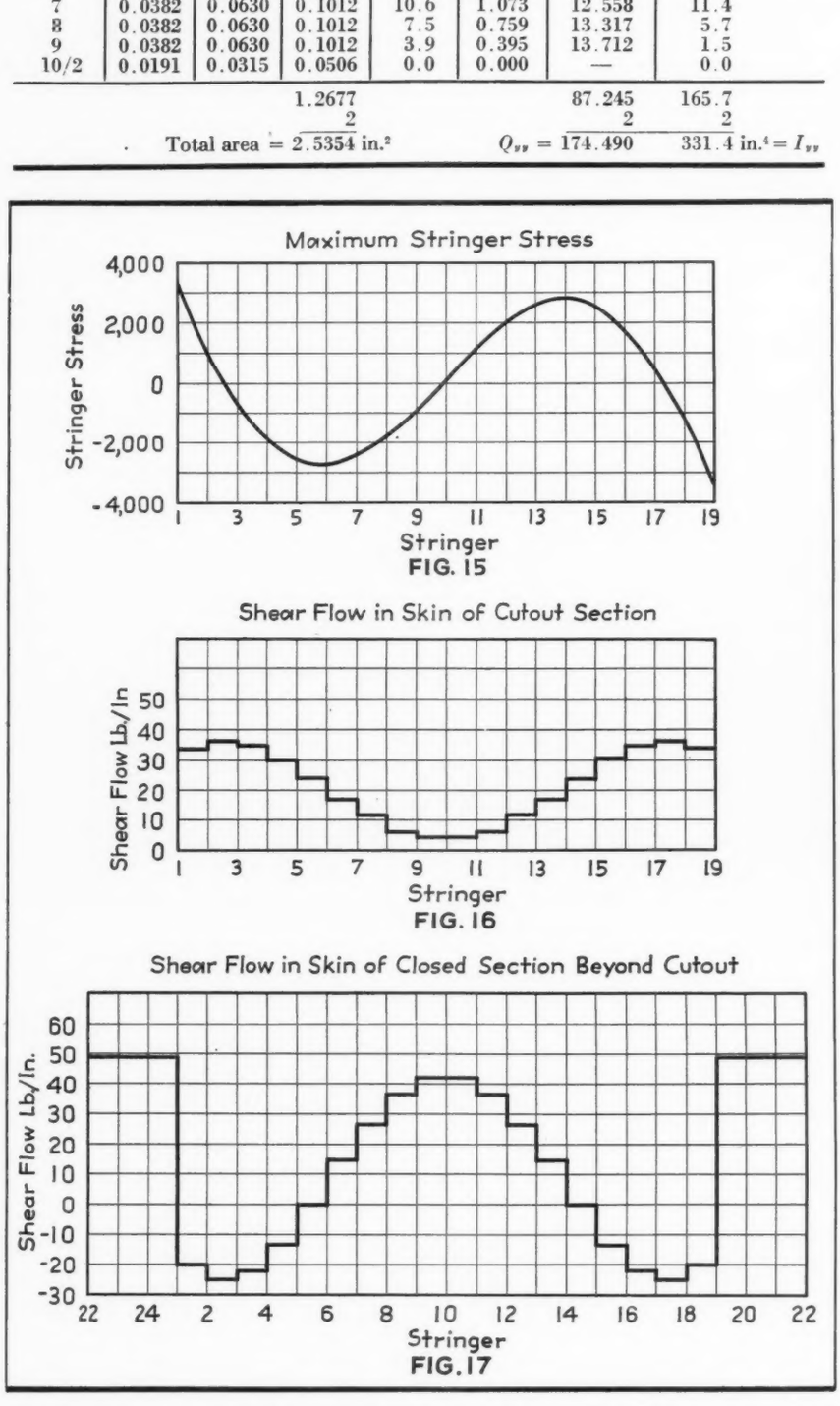


Fig. 15—Plot of a computed maximum axial stress distribution in stringers at section A-A, Fig. 13. Fig. 16—Shear flow as computed in skin of cutout section. Fig. 17—Shear flow as computed in skin of closed section beyond cutout

and 5 in Table II must be calculated to at least four significant figures in order to obtain accuracy in column 6.

The shear flows within the structure beyond the cutout as listed in Table III are obtained by the use of Equations (11) and (12).

From Equation (12)

$$T = \Sigma\, 2\, q\, \Delta S$$

$$23{,}100 = (-\,1{,}543 + 47.12\, q_0)\, 2 \times 15$$

$$q_0 = +\,49 \text{ lb. per in.}$$

The computed axial stress distribution is plotted in Fig. 15. The shear flows computed within the section having the cutout are plotted in Fig. 16. Fig. 17 is a plot of the shear flows within the structure beyond the cutout.

Experimental Verification

The Lockheed Aircraft Corporation constructed and tested the specimen shown in Figs. 13 and 14 in an effort to provide experimental data for comparison with the theoretical results.

Shear flow measurements on buckled sheet are usually unreliable mainly be-

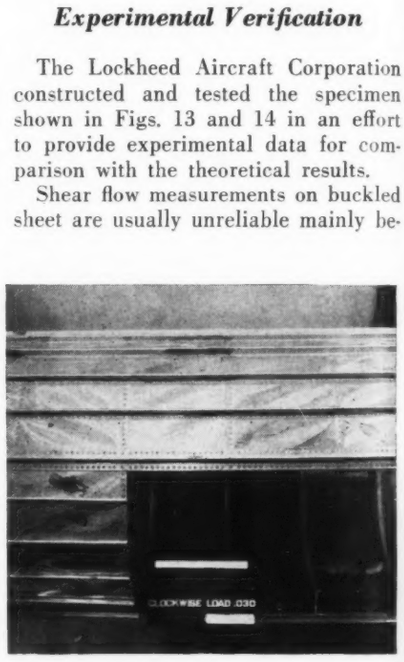


Fig. 18—Specimen subjected to a torque of +47,200 in.-lb. shows change in shear flows at the end of the cutout

cause of local bending stresses and the unknown shear moduli of the buckled panels. No effort was made to obtain shear flow readings because of these problems.

Strain readings were taken in most of the stringers at section *A-A*, Fig. 14. The effects of tension field and local bending were recorded along with the strains resulting from the axial stresses built up by torsion. These latter strains are the ones that were to be compared with the theoretical stresses given in Table II, column 14.

Experimental strains were so modified by tension field and local bending effects that the recorded values could not be used directly. Attempts were made to evaluate these secondary

Table II—Maximum Axial Stresses and Shear Flows in Cutout Structure

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Stringer or Panel	θ deg.	Sin θ	$= y \sin\theta$	$R\theta$	$\frac{f_c}{K'}$	ΔA	$\frac{P}{K'}$	$\frac{\Delta q}{K'} = \frac{(8)}{L}$	$\frac{q}{K'}$	$2\Delta\frac{S}{R}$	$\frac{q}{K'R}2\Delta S$	q	f_c	Stringer Load $= P$
			$(3)\times 31.0$	$\frac{15\,\theta}{57.3}$	$(4)-(5)$		$(6)\times(7)$	$\frac{(8)}{40}$	$\Sigma\,(9)$	$(6)_{n+1}-(6)_n$	$(10)\times(11)$	$(10)\,K'$	$(6)\,K'$	$(8)\,K'$
0	180	0.0000	00.00	47.12	−47.12	—	—	—	—	33.64	—	—	—	—
1	135	0.7071	21.92	35.40	−13.48	0.4075	−5.49	−0.1372	−0.1372	8.88	−1.218	34.3	3,370	1,372
2	120	0.8660	26.85	31.45	−4.60	0.1012	−0.47	−0.0118	−0.1490	7.04	−1.049	37.2	1,150	118
3	105	0.9659	29.94	27.50	+2.44	0.1012	+0.25	+0.0062	−0.1428	4.96	−0.708	35.7	− 610	− 62
4	90	1.0000	31.00	23.60	7.40	0.1012	0.75	0.0188	−0.1240	2.89	−0.358	31.0	−1,850	−187
5	75	0.9659	29.94	19.65	10.29	0.1012	1.04	0.0260	−0.0980	0.84	−0.082	24.5	−2,572	−260
6	60	0.8660	26.85	15.72	11.13	0.1012	1.13	0.0282	−0.0698	−1.01	+0.070	17.4	−2,782	−282
7	45	0.7071	21.92	11.80	10.12	0.1012	1.02	0.0255	−0.0443	−2.48	0.110	11.1	−2,530	−255
8	30	0.5000	15.50	7.86	7.64	0.1012	0.77	0.0192	−0.0251	−3.55	0.089	6.3	−1,910	−192
9	15	0.2588	8.02	3.93	4.09	0.1012	0.41	0.0102	−0.0149	−4.09	0.061	3.7	−1,022	−102
10	0	0.0000	0.00	0.00	0.00	0.1012	0.00	0.0000			−3.085		000	000
											2 -6.170			

stresses, but the results did not appear to be reliable and, for that reason, quantitative figures are not presented.

The test was of great value in providing qualitative information for comparison with the theory. Three principal observations were made:

1. An excellent picture of the change in shear flows at the end of the cutout is provided in Fig. 18. Figs. 16 and 17 predicted this exactly.

2. A view showing the panel where shear flow is zero and changes sign is provided in Fig. 19. This is panel 15-16

Fig. 19—Specimen subjected to a torque of −47,200 in.-lb. Note that at panel 15-16 the shear flow is zero

according to the photograph, but Fig. 17 predicted that it would be the adjacent panel 14-15. This is judged to be good agreement considering the large shear deflections of the buckled panels.

3. The theoretical stress distribution, at section *A-A*, Fig. 14, is shown in Fig. 15. The measured stress distribution was of the same general shape as the curve of Fig. 15, but the numerical values were altered by tension field and local bending effects.

These observations do not provide conclusive information upon which the theory can be judged. Additional tests must be made to determine the relative importance of various effects neglected in original assumptions. This will clarify the use and limitations of this proposed method of analysis.

Conclusions

It becomes apparent to the engineer that certain principles of design for cutout structures can be listed.

(1) The edge stringers bounding the cutout must be strengthened to take care of additional axial load resulting from the cutout. Other stringers may need strengthening; this is seen by observing Fig. 15. These effects extend beyond the cutout and should be considered in the analysis of that structure.

(2) Doublers may be necessary to carry the increased shear flow that will exist on each side of the cutout. Fig. 16 shows the variation in shear and region to be strengthened.

(3) Shear flows in the structure beyond the cutout are altered, especially in the region adjacent to it. Additional strength may be necessary in the skin; Fig. 17 shows where reinforcement may be needed.

Further refinements should account for shear deflections, bending stiffness of stringers, and the torsional stiffness of the individual stringers and skin. Probably the most important of these is the effect of shear deflections in thin skin which can be classed under the subject Shear Lag.

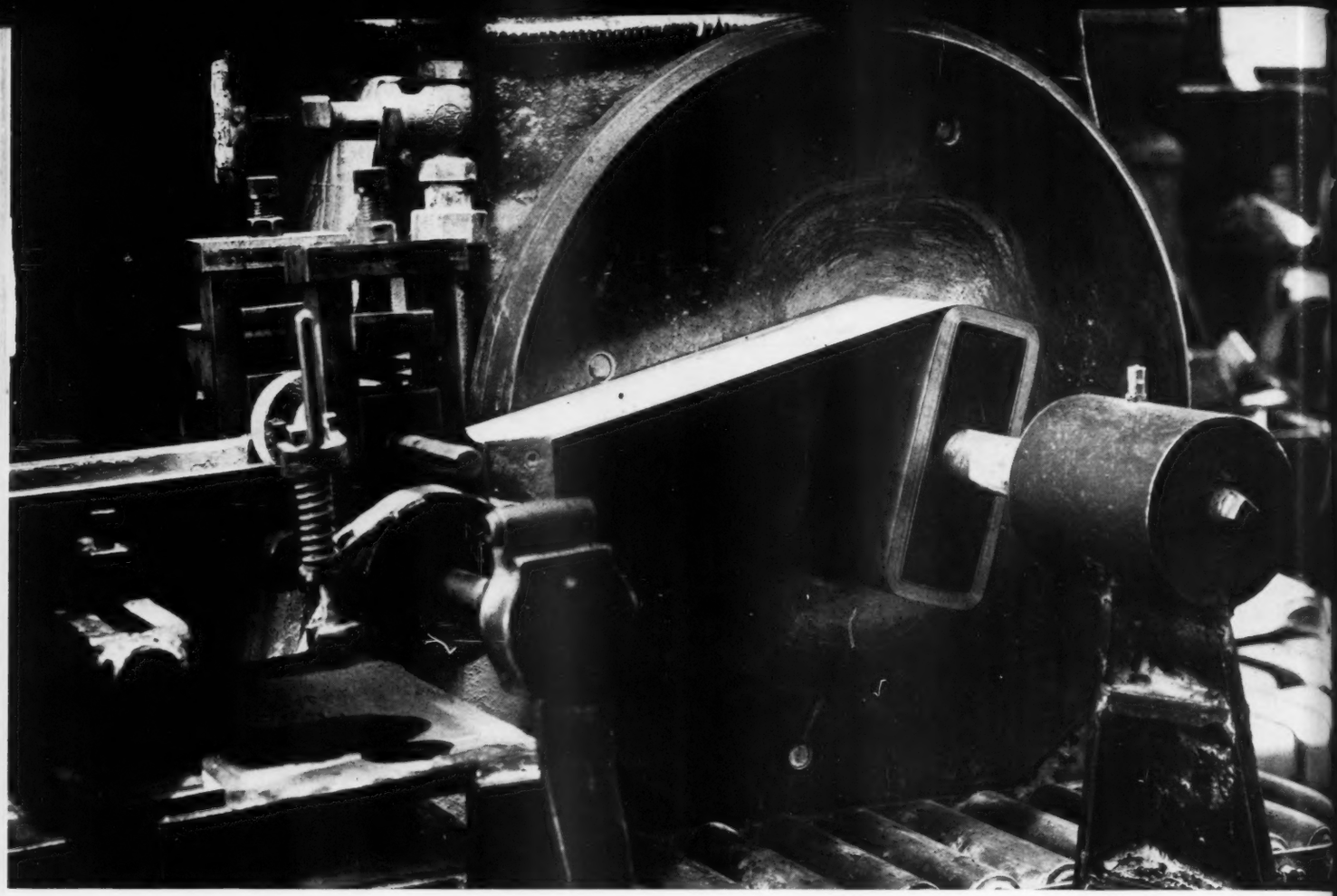
ADDITIONAL REFERENCES

(1) R. S. Hatcher, *Journal of Aeronautical Sciences*, April 1937, July 1938.

(2) Paul Kuhn, "Some Elementary Principles of Shell Stress Analysis with Notes on the Use of the Shear Center," *T.N.* 691, *NACA* 1939.

Table III—Shear Flows Beyond Cutout

1	2	3	4	5	6	7
Stringer or Panel	Stringer Load P	$\Delta q = P/L_3$	$q - q_o$	$2\,\Delta\,S/R$ Table II	$(4)\times(5)$	q
		$(2)/20$	$= -\,\Sigma(3)$			$(4)+q_o$
0	—	—	00.0	33.64	000	49
1	1,372	68.6	−68.6	8.88	−609	−20
2	118	5.9	−74.5	7.04	−524	−25
3	−62	−3.1	−71.4	4.96	−354	−22
4	−187	−9.4	−62.0	2.89	−179	−13
5	−260	−13.0	−49.0	0.84	−41	00
6	−282	−14.1	−34.9	−1.01	+35	+14
7	−255	−12.8	−22.1	−2.48	55	27
8	−192	− 9.6	−12.5	−3.55	44	37
9	−102	− 5.1	− 7.4	−4.09	30	42
				47.12	−1,543	



Better Magnetic Core Steel Aids Transformer Engineer

C. C. HORSTMAN
Transformer Engineer, Westinghouse Electric & Mfg. Company

The recent important discovery of methods of producing a magnetic core material that is capable of carrying one-third more flux than the best available grades of silicon steel with any given magnetizing force, gives the transformer engineer valuable means for improving designs of transformers.

THE transformer designer is limited by the characteristics of three materials: copper for the winding, the insulation, and the steel used in the core. Of these, the core steel offers the best opportunities for improvement in electrical properties. Such improvement may consist of greater flux carrying capacity and lower energy loss, both of which can be used to improve performance or to reduce the size and weight of the core, thus making a better transformer for a given application.

This new material, which has been tradenamed "Hipersil" by Westinghouse, is a non-retentive or magnetically "soft" material having a coercive force and hysteresis loss that are unusually low. The low density permeability of Hypersil approaches that of nickel iron alloys, and this in combination with its high density properties, gives it its advantages, particularly at present in portable equipment for our armed forces.

The improvement in this core steel was made possible by new techniques in making steel and also in the fabrication of magnetic cores. The material is a silicon steel made by a special melting, rolling and heat treating process that lines up the individual crystals in such a manner that their directions of easiest magnetization are coincident with the direction of rolling.

Since the best magnetic properties exist only in the direction of rolling, new types of core construction had to be developed to use the material. This has been done during the past year for distribution and power transformer applications. The method is illustrated in Fig. 1, which shows a strip of steel being wound as continuous ribbon on a mandrel. After the strip is wound the core is annealed to remove winding strains and then impregnated with a plastic material to bond the laminations together. The core is then cut in two,

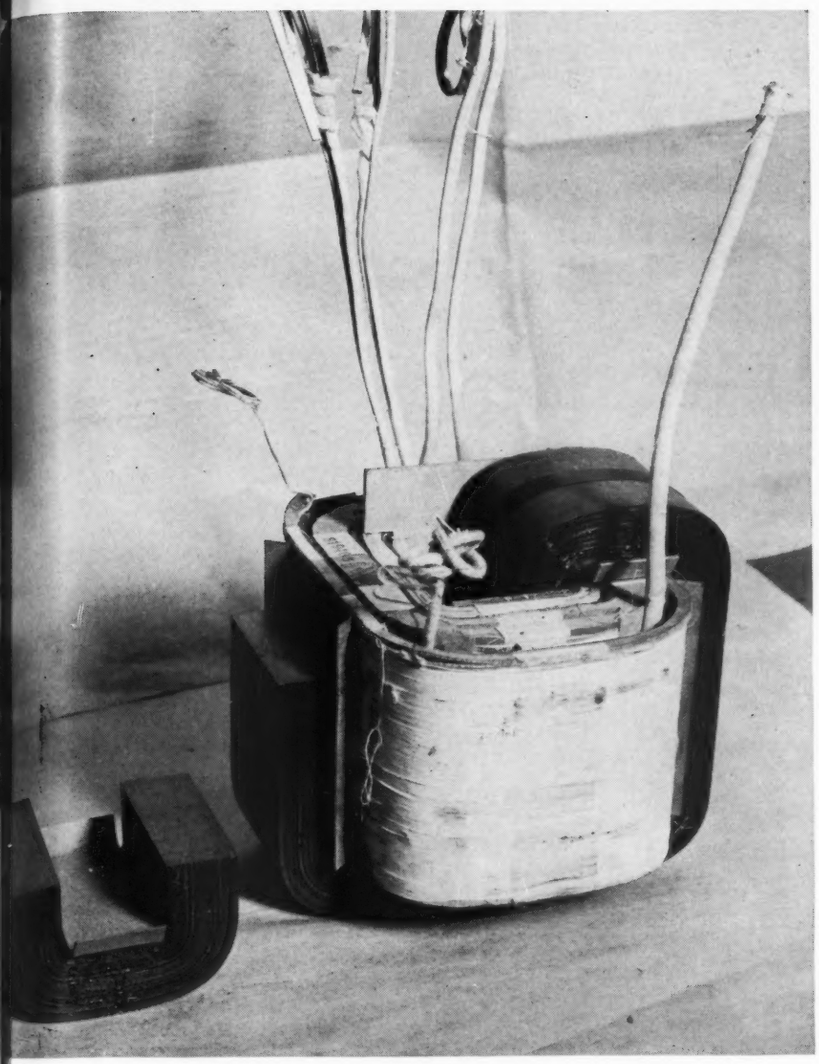
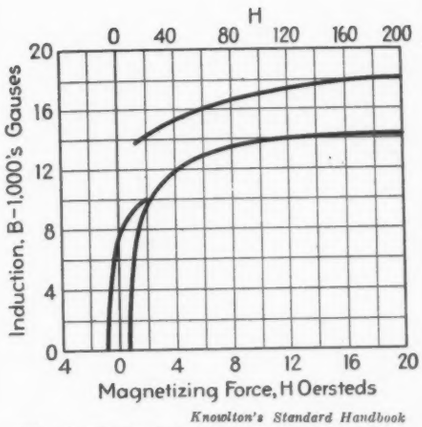
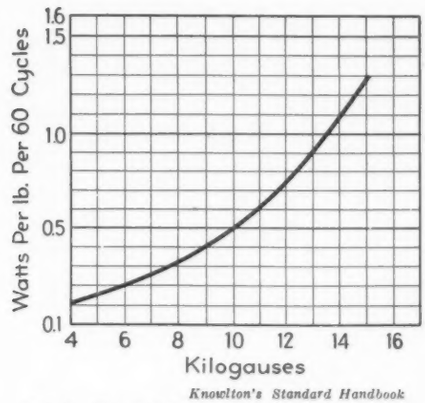


Fig. 1—(Left) Method of making improved transformer cores by winding steel strip on a mandrel. Winding strains are removed by annealing. Fig. 2—(Above) Cores must be cut in two before assembly and butt joint surfaces worked on abutting core faces



Knowlton's Standard Handbook

Fig. 4—Typical induction curve and hysteresis loop for transformer grade core sheet, No. 29 gage



Knowlton's Standard Handbook

Fig. 5—Typical loss curve for transformer A grade core sheet, No. 29 gage

as shown in Fig. 2, and butt joint surfaces worked on the abutting core faces. This type of core form is desirable for high density applications because the flux remains coincident with the best magnetic directions of the material.

Typical of the possibilities of this magnetic material in more readily producing apparatus to meet rigid size, weight and performance specifications are portable and mobile X-ray apparatus. Use of a cast transformer housing is desirable but its added weight was prohibitive when the core material was ordinary high-grade silicon steel. Substitution of this improved core material, however, permitted the design of a much smaller transformer and the use of a cast housing. Performance was improved also because of better permeability of the core material. The improved core design avoided flux distor-

Fig. 3—Visual evidence of reduced magnetic hum in Hipersil cores. A cathode-ray oscilloscope in the hands of H. V. Putman, manager of Westinghouse transformer division, demonstrates the difference in elongation (magnetostriction) of Hipersil and conventional silicon steel as magnetic induction is increased

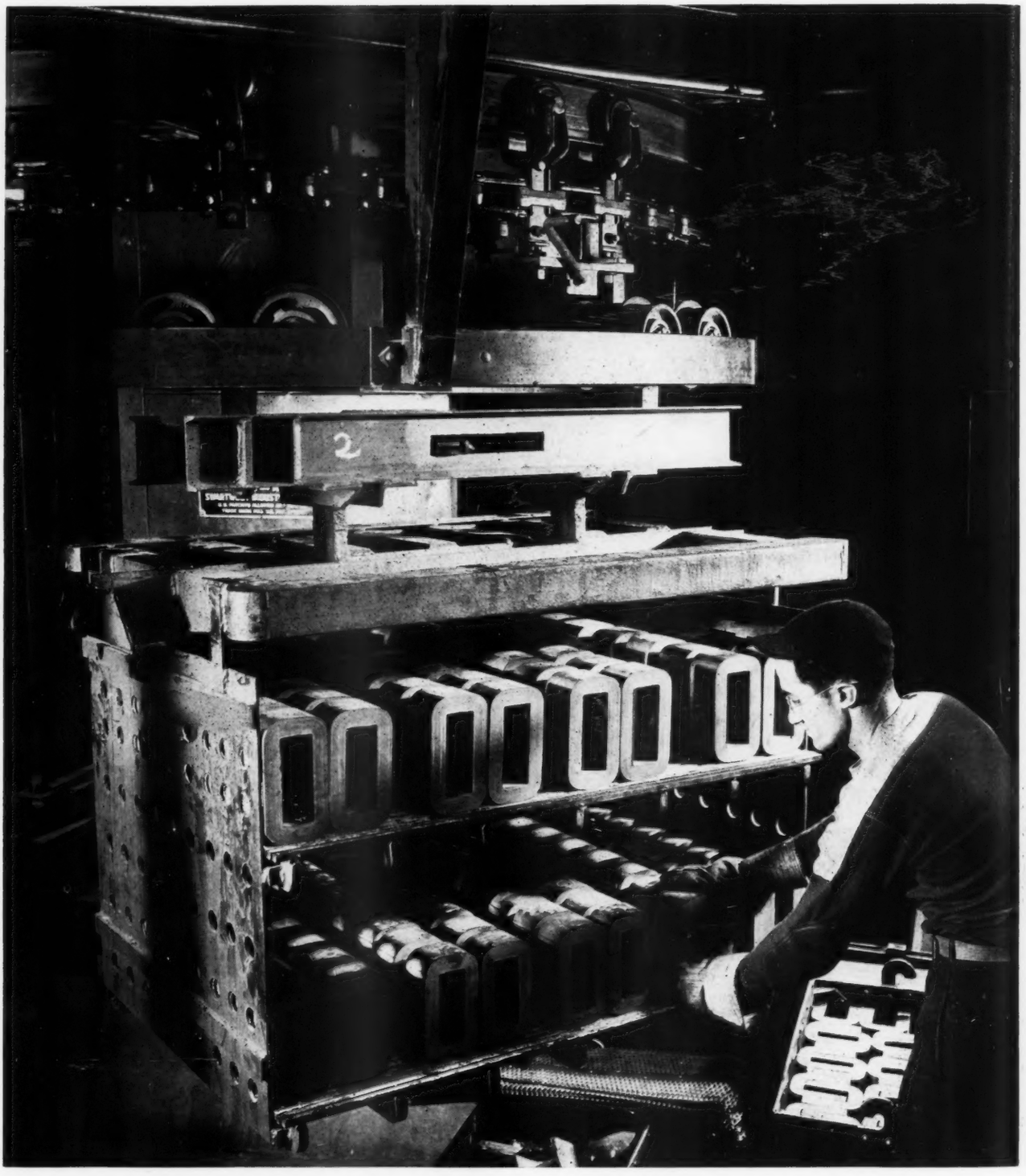


Fig. 6—Cores are stacked in this rack preparatory to impregnating with plastic compound to bond the laminations

tions at peak voltages by eliminating cross-flux, which could not be prevented entirely in the conventional type of magnetic core.

Size and weight are also of importance in transformers for street lighting service. A current transformer of about ½ kva. rating is used to isolate street lights from the high voltage series supply line and also to convert current from 6.6 to 20 amp. for the more efficient 20-amp. lamp. In this service rigid regulation is required; that is, the transformer has to regulate the current to within ± 1 percent of rated current over a lamp voltage range of 75 to 125 percent of rated voltage of the lamps in the street lighting circuit.

Using the improvement in core steel to reduce size and weight, an overall weight reduction of 15 percent was obtained for these small units, including some reduction in weight of copper windings on the smaller core. Space requirements were confined to one dimension: a reduction from 9 to 8½ in. in length.

Effect of Material and Loading In Calculating Design Stress

GEORGE H. NEUGEBAUER
Department of Machine Design, Cooper Union

Design stress formulas applicable to any member subject to steady or variable loads, wherever the shear and tension stresses or stress ratios can be determined, are developed and discussed in relation to other factors. The formulas give stresses in brittle and ductile materials, taking into account the effect of steady and variable loads, of stress concentrations, and combined normal and shear stresses.

PROPER determination of design stresses in machine members must come as the result of consideration of many factors. Although, in the final analysis, the choice of design stresses depends on the judgment and experience of the designer, the job is simplified if some of the variables are removed from the realm of judgment factors and placed on a more solid footing. This has been accomplished for some factors, but no previous article, to the writer's knowledge, has been written to aid in making practical use of the results of the investigations. Thus, the effect of steady and repeated loads, and the effect of stress concentrations can, in most cases, be directly determined. Factors such as danger to life and property, quality of workmanship, and uncertainties of loading are entirely matters of engineering judgment. This article is confined to the effect of steady and repeated loading, and of stress concentration on both brittle and ductile materials.

I—FACTORS AFFECTING CHOICE OF DESIGN STRESSES

A. Type of material. (1) Physical properties such as elastic limit, yield point, ultimate stress, endurance limit, and ductility; (2) Homogeneity; (3) Corrosion resistance and electro-chemical properties; (4) Deviations from specifications; (5) Size effect on strength.

B. Type of load. (1) Steady or dead loads; (2) Variable or repeated loads; (3) Overloads—peak loads and accidental overloads; (4) Suddenly applied and impact loads; (5) Buckling loads due to instability of member.

C. Uncertainty of loads.

D. Validity of stress analysis—assumptions implied in stress equations.

E. Initial stresses, assembly stresses, and stresses due to handling.

F. Stress concentrations due to keyways, notches, oil holes, shoulders, force or shrink fits, tool marks, etc.

G. Temperature effects. (1) Creep and loss of strength at high temperatures; (2) Brittleness at low temperatures; (3) Stresses induced due to temperature changes or temperature gradients.

H. Economy of weight or material.

J. Quality of workmanship and manufacturing tolerances.

K. Danger to life and property.

In addition to these more common factors there may be other considerations such as rigidity, resonance, transmissibility, etc.

II—STEADY LOADS—BRITTLE MATERIALS

The strength of brittle materials is usually based on the maximum stress theory. This theory states that the member will fail when the maximum principal stress is equal to the stress in a simple tension test specimen at failure. Failure stress is considered by some to be the ultimate stress. Others consider the member to have failed in an engineering sense at the yield point. The latter definition is based on the assumption that failure occurs when the member ceases to perform its allotted function and that most machine elements will not properly perform after they have been permanently deformed. A brittle material does not have a definite yield point but it is often considered that a stress which causes a permanent deformation of 0.2 percent is its yield point. In this article, the design stresses of brittle materials are based on their ultimate strengths.

Most homogeneous brittle materials are sensitive to stress concentrations even for steady loads and this effect must be considered in determining the nominal design stress. Cast iron and possibly other similar non-homogeneous metals are exceptions since they have so many internal discontinuities as to be insensitive to additional stress raisers. For such materials stress concentration factors may be taken as equal to unity.

Let σ_0 = nominal normal stress on a small element of a given member, this normal stress may be either positive or negative, that is, tensile or compressive, and may be due to direct loading, bending, centrifugal or other loads. Let k_σ = the stress concentration factor for the normal stress at this element.

Let τ_0 = nominal shear stress on the same element, this shear stress may be due to direct shear, torsion, or other loads. Let k_τ = the stress concentration factor for the shear stress at this element.

Fig. 1 (*a*) shows an element subjected to a combined normal stress $k_\sigma\sigma_0$ and shear stress $k_\sigma\tau_0$. It can easily be shown (Ref. 2) that a plane at some angle α, as in Fig. 1 (*b*), will have a maximum principal stress of

$$\sigma_1 = \frac{k_\sigma \sigma_0 \pm \sqrt{(k_\sigma \sigma_0)^2 + 4 (k_\tau \tau_0)^2}}{2} \qquad (1)$$

The sign of the radical is chosen so as to make σ_1 a numerical maximum. Thus, when σ_0 is a compressive stress (negative), then the negative sign would be used.

The value of σ_1 must be less than the ultimate strength σ_u. That is, the maximum design stress is equal to the ultimate strength divided by a factor of safety n. The value of n must be based on a consideration of all the factors listed in section I except material, load, and stress concentration factors, which are accounted for in Equation (1). In general, the factor of safety would not be less than four (based on ultimate strength) except under unusual circumstances.

$$\sigma_1 = \frac{\sigma_u}{n} = \frac{k_\sigma \sigma_0 \pm \sqrt{(k_\sigma \sigma_0)^2 + 4 (k_\tau \tau_0)^2}}{2} \qquad (2)$$

Often the ratio of the nominal shear

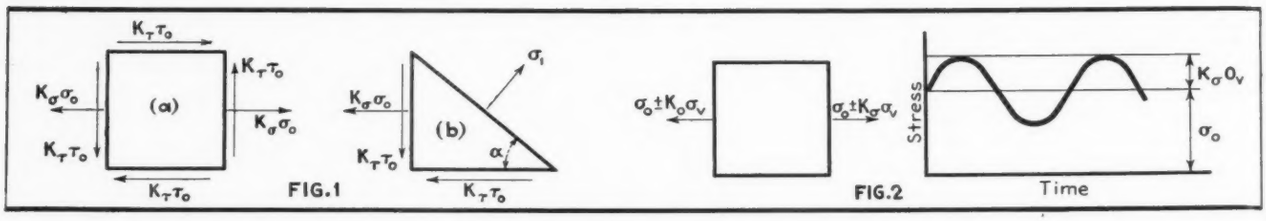


Fig. 1—Element subjected to a combined stresses and a plan ein this element at any angle
Fig. 2—Varying stress plotted against time. Components of repeated normal stresses

stress τ_o to the normal stress σ_o is known from a consideration of the loads. In this case Equation (2) may be put into a more useful form by solving for the nominal normal stress.

$$\sigma_o = \frac{2\,\sigma_e}{n\,k_\sigma\left[1+\sqrt{1+4\left(\frac{k_\tau}{k_\sigma}\cdot\frac{\tau_o}{\sigma_o}\right)^2}\right]} \quad (3)$$

The value of σ_o is determined from Equation (3) and the size of the member is based on that load which caused the nominal normal stress, σ_o

If there are only occasional overloads, the member may be designed on the basis of the normal steady load and then checked for overloads. The factor of safety on such overloads may be smaller than that for normal loads, according to the judgment of the designer, but should not be less than four except under unusual circumstances.

III—STEADY LOADS—DUCTILE MATERIALS

The strength of ductile materials is usually based on the maximum shear stress theory (Ref. 3). This theory states that a member will fail when the maximum shear stress is equal to the shear stress in a simple tension test specimen at failure. In this article, however, the design stresses of ductile materials are based on yield strength.

The maximum shear stress τ_y in a simple tension test specimen at failure is equal to one-half the normal stress σ_y at failure, where failure is considered to occur at the yield point, that is,

$$\tau_y = \frac{\sigma_y}{2} \quad (4)$$

The strength of ductile members subjected to steady loads only are not greatly affected by stress concentrations since local yielding relieves the stress (Ref. 4, 5). Therefore, stress concentration factors can usually be neglected.

If the stress distribution is that shown in Fig. 1 (*a*) with stress concentration factors neglected, then a plane at some angle β will have a maximum shear stress of

$$\tau_1 = \sqrt{\left(\frac{\sigma_0}{2}\right)^2+\tau_0^2} = \frac{\sigma_0}{2}\sqrt{1+4\left(\frac{\tau_0}{\sigma_0}\right)^2} \quad (5)$$

Value of τ_1 must be less than the yield point shear stress τ_y in simple tension divided by a factor of safety n. Value of n must be based on a consideration of all the factors listed in section I but would not be less than two except under unusual circumstances. Then from Equations (4) and (5):

$$\tau_1 = \frac{\tau_y}{n} = \frac{\sigma_y}{2n} = \sqrt{\left(\frac{\sigma_0}{2}\right)^2+\tau_0^2} \quad (6)$$

If the ratio of shear stress τ_0 to normal stress σ_0 is known from a consideration of the loads, then Equation (6) may be put into a more useful form by solving for the normal stress,

$$\sigma_0 = \frac{\sigma_y}{n\sqrt{1+4\left(\frac{\tau_0}{\sigma_0}\right)}} \quad (7)$$

The value of σ_0 can be determined from Equation (7) and the size of the member is based on the load which causes the stress.

IV—VARIABLE LOADS—DUCTILE MATERIALS

While fatigue failures of even ductile materials have the appearance of brittle failures, Gough's work on the fatigue of single crystals shows that fatigue failure is generally preceded by slip on planes having maximum resolved shear stress (Ref. 6). Tests of low-carbon steels subjected to combined alternating torsion and alternating bending have produced results agreeing closely with the shear-strain energy theory. However, the maximum shear-stress theory is so simple and so seldom gives results differing more than a few percent from the shear strain energy theory, that it is considered advisable to use it as a basis for the determination of design stresses.

Normal Stresses

The determination of design stresses under variable loads must take both the yield point and the endurance limit into consideration. The stresses due to varying loads may be resolved into two components: a mean stress σ_0 and a variable or repeated stress $k_\sigma\sigma_v$. (Ref. 7, 8). In accordance with present day theory, the stress concentration factors are applied only to the variable stress component in a ductile material. Fig. 2 shows an idealized varying stress, which may be thought of as a variable stress of amplitude $k_\sigma\sigma_v$ superimposed on a mean steady stress σ_0, plotted against time.

Plotting the combination of steady and variable stress corresponding to failure, as shown by the upper line in Fig. 3, appears reasonable since, from the few data known, it is on the safe side. The actual curve of failure joining σ_y (yield point) and σ_e (endurance limit) is probably a curved line, but it is easier and safer to treat this as a straight line (Ref. 5).

Equation of this line of failure is

$$\frac{\sigma_0}{\sigma_y}+\frac{k_\sigma\sigma_v}{\sigma_e}=1 \quad (8)$$

which expresses the combination of a mean steady stress σ_0 and a superimposed varying stress of amplitude $k_\sigma\sigma_v$ that will cause failure. Thus either a steady stress alone of $\sigma_0 = \sigma_y$ or a completely reversed stress $k_\sigma\sigma_v = \sigma_e$ would cause failure. Also, such a combination of a mean stress $\sigma_0 = OA$ and a varying stress of amplitude $k_\sigma\sigma_v = OB$ would cause failure. A factor of safety n is determined by a consideration of the factors listed in section I with the exception of those for material, load, and stress concentration factors which are accounted for in the equations given below. The factor of safety chosen is applied giving us a line joining the points σ_y/n and σ_e/n, the lower inclined

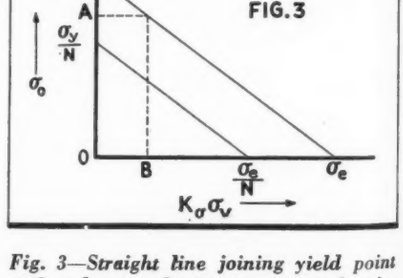


Fig. 3—Straight line joining yield point and endurance limit is easier and safer to treat than the actual curved line

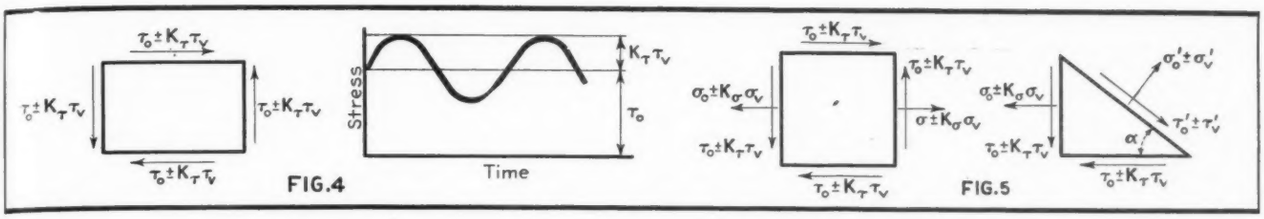


Fig. 4—Element subjected to variable shear stress of amplitude $k_\tau\tau_v$ superimposed on a mean steady shear stress. Fig. 5—A common example of combined tension and shear

line of Fig. 3. Equation of this line is

$$\frac{\sigma_0}{\sigma_y} + \frac{k_\sigma \sigma_v}{\sigma_e} = \frac{1}{n} \tag{9}$$

If, as is usual, the ratio of the loads causing σ_0 and σ_v is known, then the ratio of the stresses can be determined and Equation (9) can be put into a more useful form:

$$\sigma_0 = \frac{\sigma_y}{n\left[1 + k_\sigma\left(\frac{\sigma_v}{\sigma_0}\right)\left(\frac{\sigma_y}{\sigma_e}\right)\right]} \tag{10}$$

In any particular problem in which there is only a normal varying stress, the values of σ_y, σ_e, and the ratio of σ_v to σ_0 are known, the value of σ_0 is determined from Equation (10). The size of the member is then based on the mean steady load, which causes the mean steady stress.

In case $\sigma_0 = 0$, that is, the member is subjected to a completely reversed loading, Equation (10) is indeterminate and Equation (11) must be used.

$$\sigma_v = \frac{\sigma_e}{k_\sigma n} \tag{11}$$

The size of the member is thus based on the amplitude of the completely reversed load, which causes the nominal variable stress.

Shear Stresses

Fig. 4 shows an element subjected to a variable shear stress of amplitude $k_\tau\tau_v$ superimposed on a mean steady shear stress of τ_0.

The ratio of endurance limits τ_e and σ_e obtained from torsion tests and from bending tests (Ref. 9, 10) averages somewhat greater than one-half or $\tau_e \approx \sigma_e/2$. Also, by the maximum shear stress theory which is being used for ductile metals the yield point stress τ_y in shear is equal to one-half the yield stress σ_y in simple tension.

The line of failure may justifiably be defined as that line which joins τ_y and τ_e in a manner similar to that shown in Fig. 3. The equation of this line is

$$\frac{\tau_0}{\tau_y} + \frac{k_\tau \tau_v}{\tau_e} = 1$$

or

$$\frac{2\,\tau_0}{\sigma_y} + \frac{2\,k_\tau\,\tau_v}{\sigma_e} = 1 \tag{12}$$

which expresses the combination of a mean steady shear stress τ_0 (and a superimposed varying shear stress) of amplitude $k_\sigma\tau_v$ that will cause failure.

Again a factor of safety n is determined from a consideration of the factors listed in section I. Then the line of safety becomes

$$\frac{2\,\tau_0}{\sigma_y} + \frac{2\,k_\tau\,\tau_v}{\sigma_e} = \frac{1}{n} \tag{13}$$

If, as is usual, the ratio of the loads causing τ_0 and τ_v are known, then the ratio of the stresses may be determined, and Equation (13) can be put into the more useful forms

$$\tau_0 = \frac{\sigma_y}{2n\left[1 + k_\tau\left(\frac{\tau_v}{\tau_0}\right)\left(\frac{\sigma_y}{\sigma_e}\right)\right]} \tag{14}$$

$$\tau_v = \frac{\sigma_e}{2n\left[\left(\frac{\tau_0}{\tau_v}\right)\left(\frac{\sigma_e}{\sigma_y}\right) + k\tau\right]} \tag{15}$$

Combined Stresses

Fig. 5(*a*) shows an element subjected to a combined normal stress $\sigma_0 \pm k_\sigma\sigma_v$ and shear stresses $\tau_0 \pm k_\sigma\tau_v$ (Ref. 11).

Considering only the mean stresses σ_0 and τ_0, the value of the mean shear stress τ_0' on a plane at any angle α is

$$\tau'_0 = \frac{\sigma_0}{2}\sin 2\alpha + \tau_0 \cos 2\alpha \tag{16}$$

Similarly, the amplitude of the variable stress component τ_v' on this plane is

$$\tau'_v = \pm\left[\frac{k_\sigma\,\sigma_v}{2}\sin 2\alpha + k_\tau\,\tau_v \cos 2\alpha\right] \tag{17}$$

Substitution of Equations (16) and (17) in Equation (13) gives

$$\frac{1}{n} = \frac{\sigma_0 \sin 2\alpha + 2\tau_0 \cos 2\alpha}{\sigma_y} + \frac{k_\sigma\,\sigma_v \sin 2\alpha + 2k_\tau\,\tau_v \cos 2\alpha}{\sigma} \tag{18}$$

The factor of safety n will be a minimum when $\dfrac{\partial \frac{1}{n}}{\partial \alpha} = 0$. Under this condition

$$\tan 2\alpha = \frac{\frac{\sigma_0}{\sigma_y} + k_\sigma\frac{\sigma_v}{\sigma_e}}{2\left[\frac{\tau_0}{\sigma_y} + k_\tau\frac{\tau_v}{\sigma_e}\right]} \tag{19}$$

This value of α in Equation (18) gives Equation (20) in the accompanying table.

Equation (20) may be used for determining design stresses for the combination of stresses shown in Fig. 5. In any particular problem the desired factor of safety is based on a consideration of the factors listed in section I and the judgment of the designer. Often the ratios of the mean and variable stresses may be obtained if the ratio of the loads are known. Equation (20) may then be put in the more useful forms of Equations (21) and (22).

The value of the mean normal stress σ_0 is obtained from Equation (21) and the size of the member is based on the mean steady load that causes the nominal stress σ_0. Or, the value of the amplitude of the nominal variable stress σ_v is obtained from Equation (22) and the size of the member is based on the amplitude of the variable load which causes the nominal variable stress σ_v. The above equations hold for either tensile or compressive stresses. In the case of a mean compressive stress σ_0 a negative sign must be given to the values of σ_0, σ_e and σ_y.

An illustration of the method of application of these equations is a rotating steel shaft subjected to complete

$$\frac{1}{n} = \sqrt{\left[\frac{\sigma_0}{\sigma_y} + k_\sigma\frac{\sigma_v}{\sigma_e}\right]^2 + 4\left[\frac{\tau_0}{\sigma_y} + k_\tau\frac{\tau_v}{\sigma_e}\right]^2} \tag{20}$$

$$\sigma_0 = \frac{\sigma_y}{n\sqrt{\left[1 + k_\sigma\left(\frac{\sigma_v}{\sigma_0}\right)\left(\frac{\sigma_y}{\sigma_e}\right)\right]^2 + 4\left[\frac{\tau_0}{\sigma_0} + k_\tau\left(\frac{\tau_v}{\sigma_0}\right)\left(\frac{\sigma_y}{\sigma_e}\right)\right]^2}} \tag{21}$$

or

$$\sigma_v = \frac{\sigma_e}{n\sqrt{\left[\left(\frac{\sigma_0}{\sigma_v}\right)\left(\frac{\sigma_e}{\sigma_y}\right) + k_\sigma\right]^2 + 4\left[\left(\frac{\tau_0}{\sigma_v}\right)\left(\frac{\sigma_e}{\sigma_y}\right) + k_\tau\frac{\tau_v}{\sigma_v}\right]^2}} \tag{22}$$

$$\frac{1}{n} = \sqrt{k_\sigma^2\left[\frac{2\,\sigma_0}{\sigma_u} + \frac{\sigma_v}{\sigma_e}\right]^2 + 4\,k_\tau^2\left[\frac{2\,\tau_0}{\sigma_u} + \frac{\tau_v}{\sigma_e}\right]^2} \tag{23}$$

$$\sigma_0 = \frac{\sigma_u}{2n\sqrt{k_\sigma^2\left[1 + \left(\frac{\sigma_v}{\sigma_0}\right)\left(\frac{\sigma_u}{2\,\sigma_e}\right)\right]^2 + 4\,k_\tau^2\left[\frac{\tau_0}{\sigma_0} + \left(\frac{\tau_v}{\sigma_0}\right)\left(\frac{\sigma_u}{2\,\sigma_e}\right)\right]^2}} \tag{24}$$

$$\sigma_v = \frac{\sigma_v}{n\sqrt{k_\sigma^2\left[\left(\frac{\sigma_0}{\sigma_u}\right)\left(\frac{2\,\sigma_v}{\sigma_u}\right) + 1\right]^2 + 4\,k_\tau^2\left[\left(\frac{\tau_0}{\sigma_v}\right)\left(\frac{2\,\sigma_v}{\sigma_u}\right) + \frac{\tau_v}{\sigma_v}\right]^2}} \tag{25}$$

reversals of stress due to a bending moment $M = \pm$ 100,000 in. lb. and a torque $T \pm 0.1\,T = 200{,}000 \pm 20{,}000$ in. lb. It has a yield point $\sigma_y = 40{,}000$ lb. per sq. in. and an endurance limit $\sigma_e = 35{,}000$ lb. per sq. in. There is a change in section such that $k_\sigma = k_\tau = 2$. The factor of safety $n = 2$. Then:

$$\sigma_0 = 0 \quad \tau_0 = \frac{16\,T}{\pi\,d^3}$$

$$\tau_v = \frac{16\,(0.1)\,T}{\pi\,d^3} \quad \sigma_v = \frac{32\,M}{\pi\,d^3}$$

Therefore

$$\frac{\sigma_0}{\sigma_v} = 0 \quad \frac{\sigma_v}{\sigma_v} = \frac{35{,}000}{40{,}000} = 0.875$$

$$\frac{\tau_0}{\sigma_v} = \frac{T}{2\,M_v} = 1 \quad \frac{\tau_v}{\sigma_v} = \frac{1.6\,T}{32\,M} = 0.1$$

From Equation (22)

$$\sigma_v = \frac{35{,}000}{2\sqrt{(0+2)^2 + 4\,[(1)(0.875) + 2\,(0.1)]^2}}$$

$$= 5{,}950 \text{ lb. per sq. in.}$$

$$d^3 = \frac{32\,M}{\pi\,\sigma_v} = \frac{32 \times 100{,}000}{\pi \times 5{,}950} = 171$$

Therefore $d = 5.55$ in.

It should be noted that the above generalized analysis resulting in Equations (20), (21) and (22) applies without change, not only to circular shafts in combined bending and twisting, but to any member whenever the shear and normal stresses or stress ratios can be determined from the external load.

From the above illustrative example, it is seen that these equations, when applied in actual design, reduce to simple numerical expressions, giving desired member-dimension.

For safe design, care should be taken to locate the point in the stressed member at which the combined loading effect is a maximum. For example, in a cantilever beam 2 in. wide x 4 in. high, subjected to twist combined with bending in the vertical plane, the maximum torsional shear stress and the maximum bending stresses do not occur at the same point. Maximum torsional shear stress occurs at the center of the side faces while maximum bending stresses occur on the top and bottom faces at the support. A few trials at various points in the cross-section will locate the most heavily stressed point produced by the combined loads. The generalized Equations (20), (21) and (22) are also applicable—an indication of their wide scope of usefulness.

Variable Loads—Brittle Material

The determination of design stresses for a brittle material subjected to a variable load presents several problems. No definitive data have been obtained as to the effect of stress concentrations on a brittle material subjected to a varying load. Also, it is uncertain which theory of failure should be applied, or what line might be considered as being the line of failure (Ref. 11).

Apparently if a brittle material subjected to a steady stress is affected by stress concentrations, then both the mean stress and the varying stress components should be multiplied by the stress concentration factors. It will be evident from the ensuing discussion that Equations (20), (21) and (22) of the previous section may be applied to cast iron, which is unaffected by stress concentrations for a steady load, with σ_y replaced by $\sigma_u/2$ (Ref. 1, 12).

The maximum principal stress theory could probably be assumed to be as good a criterion of failure for a variable stress as for a steady stress. However, the design stress equations obtained by the maximum principal stress theory, while not giving results which differ much from the maximum shear stress theory, are unwieldy. For these reasons, it appears satisfactory to use the maximum shear stress theory of failure.

The usual minimum factor of safety used by designers for brittle materials under a steady load is four, based on the ultimate strength. The usual minimum factor of safety for completely reversed loads is two, based on the endurance limit. Therefore, if the line of failure used for brittle materials be that joining $\sigma_u/2$ and σ_e, the results would be consistent with present design practice.

The design stress equations may be derived in much the same way as that shown in section IV for ductile materials. These are Equations (23), (24) and (25) in the accompanying table.

The value of the mean normal stress σ_0 is obtained from Equation (24) and the size of the member is based on the mean steady load which causes the mean nominal stress σ_0. Or, the value of the amplitude of the nominal variable stress σ_v is obtained from Equation (25) and the size of the member is based on the load which causes the nominal variable stress σ_v.

The minimum factor of safety, since it is based on a failure line joining $\sigma_u/2$ and σ_e, should not be less than two except under unusual circumstances.

It should be noted that Equations (20), (21) and (22) for ductile materials subjected to combined stresses, and Equations (23), (24) and (25) for brittle materials subjected to combined stresses, have been developed on the assumption that the variable normal and shear stresses were in phase. It is a reasonable assumption since in most cases the loads causing the variable stresses are in phase. In any case, it is a simplification and leads to no great error. The equations are for the most common two-dimensional stress system, but the same type of analyses, if necessary, could be applied to the more general two dimensional stress system.

These equations are intended for everyday use. Cases warranting the time and effort required by more elaborate theories are unusual.

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Causes and Cures

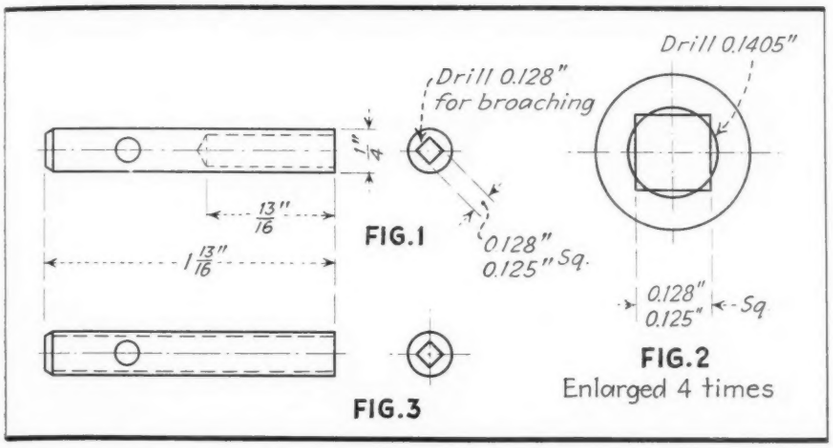
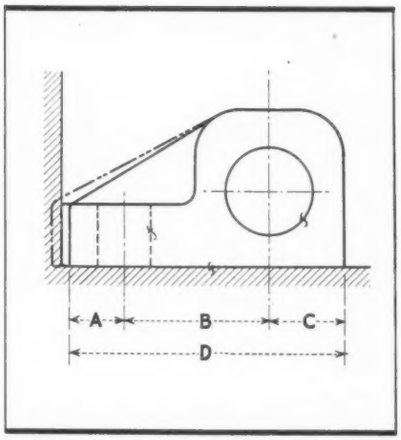


FIG.1

FIG.2
Enlarged 4 times

FIG.3



Broached hole in an aircraft part was originally detailed as in Fig. 1. The hole was blind, with the width of the square broach equal to the diameter of the drilled hole. No provisions were made for chip clearance. As a result, four broaches were required. The operator could only advance the broach ⅛ in. before he had to back it out and blow out the chips. Design was improved by drilling out to diameter of 0.1405 as in Fig. 2, providing some clearance. This permitted use of one roughing and one finishing broach in a punch-press set-up. Hole could be broached to full depth with one stroke. Fig. 3 shows a further improvement in design. Hole 0.128 in. dia. is now drilled clear through the sleeve. Whenever designing for a broached hole, provisions must be made for chip removal.

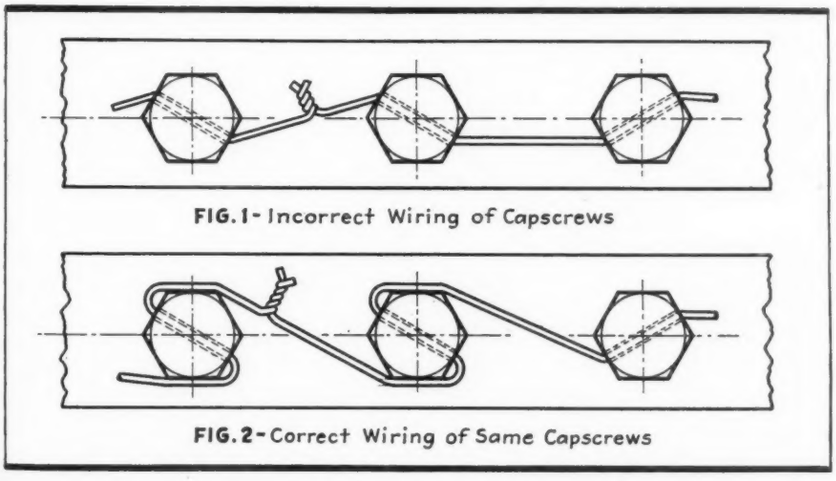


FIG.1- Incorrect Wiring of Capscrews

FIG.2- Correct Wiring of Same Capscrews

Designers should specify correct procedure for wiring capscrews and studs on vibrating elements. An unthinking mechanic will almost invariably pass locking wire through holes in the heads of capscrews or nuts by the most direct route. Wire tension often tends to rotate the capscrews or studs backwards as shown by the first two capscrews of Fig. 1. The wire should be arranged so that it tends to tighten all the screws as in Fig. 2. If this is not considered neat enough, the holes should be drilled at assembly, or three holes 120 deg. apart can be drilled in each capscrew head. Wiring laced through drilled studs and nuts is preferred to the use of cotterpins because the wire will prevent rotation of the stud as well as the nut.

Castings should be dimensioned so that any oversize unmachined dimensions will not interfere in assembly. For the casting shown above, all dimensions *A*, *B*, *C* and *D* were given on the drawing. The casting delivered by the foundry was oversize as shown dotted. The machinist marked off the work from the right-hand end, maintaining dimension *C*, but putting all extra length in dimension *A*. The ends were not machined. At assembly the left end of the casting fouled the adjacent piece because very little clearance had been allowed. The casting had to be chipped. Recurrence of the trouble was prevented simply by omitting dimension *C*, which did not need to be exact.

GENERATOR DRIVE FOR A NEW ENGINE caused trouble. The teeth on the laminated plastic drive gear would shear off after anywhere from 10 to 100 hr. test run. Recalculation of the loads on the teeth showed no excessive loading. Substitution of steel drive gear for the composition gear did not help; after running a few hours with the steel gear, the armature shaft itself failed. This indicated that the cause might be the compound effect of a torsional vibration in the crankshaft coming in resonance with the armature shaft. Consequently, the gear was mounted on a rubber bushing capable of dampening out small vibrations, and the trouble ceased.

PRODUCT ENGINEERING will pay a minimum of $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.

Safe Beam Loading For Aluminum Tubes

MARSHALL HOLT

Research Engineer, Aluminum Company of America

Effects of loading methods on tubular aluminum beams are determined by means of laboratory test values of modulus of failure of 17S-T tubular beams. The modulus is found to agree reasonably well with data in ANC-5 when the beam is loaded in such a way that a length of at least three diameters is subject to uniform bending moment. If the loading condition is equivalent to a single concentrated load, and the tube is supported against damage at points of concentrated load, there is an extra margin of safety

ALTHOUGH the modulus of failure is in many cases only a fictitious stress, it affords a convenient means of comparing the beam strengths of various materials and the effects of various loading conditions. For this discussion, the modulus of failure will be defined as the value of the maximum stress obtained from the ordinary beam formula when the bending moment obtaining at the maximum load is used.

The modulus of failure of a given material does not have a constant value in the same sense that the tensile strength of a material is practically constant for various cross-sections and various methods of fabrication. In a beam test, as in a compression test, the ultimate strength of a specimen is a function of the shape and proportions of the cross-section. For example, tubular specimens with high radius-thickness ratios may fail by buckling at maximum stresses in the elastic range, whereas solid rectangles or rounds may develop values of modulus of failure greater than the tensile strength of the material. "Strength of Aircraft Elements, ANC-5" gives relations between the modulus of failure for round tubing and the diameter-thickness ratio for materials having properties equal to the specification values.

In order to determine the effects of the method of loading on the value of the modulus of failure, some tests were made at the Aluminum Research Laboratories on aluminum alloy 17S-T round tubing. The load was distributed variously: in some tests it was applied as a single concentrated load at the center of a simple span; in other tests it was divided into two equal concentrated loads at the third-points of the span; and in still other tests as two equal loads at the outer sixth-points. Care was taken to provide for relatively large deflections without restraint by loading the beam through knife-edges lying along horizontal diameters of the specimen. In all cases, the loading mechanism allowed practically free longitudinal movement of the load points as the specimens deflected. The cross-section was held circular at the points of concentrated load by means of snugly fitting collars. In Fig. 1 is shown the test arrangement for applying the load at the third-points of the span of a short length of tubing.

The tubing tested was 2 in. in outside dia. and 0.083 in. in wall thickness. The tensile strength of the material as determined by tests on specimens of the full cross-section was 64,600 lb. per sq. in. and the tensile yield strength (0.2 percent offset) was 45,500 lb. per sq. in. The compressive strength as determined on a specimen of the full cross-section having a slenderness ratio of 10 was 54,700 lb. per sq. in. and the compressive yield strength was 38,500 lb. per sq. in. at 0.2 percent offset.

In the beam tests, span lengths of 10 and 20 dia. were used. The maximum loads and the moduli of failure are given in Table I. It will be seen that with center-point loading the values of modulus of failure are considerably greater than those for the third and sixth-point loadings; also they are greater than either the tensile or compressive strengths of the material. The two values for the third-point loading and that for the sixth-point loading on the 40-in. span are in reasonable agreement. The variation is not

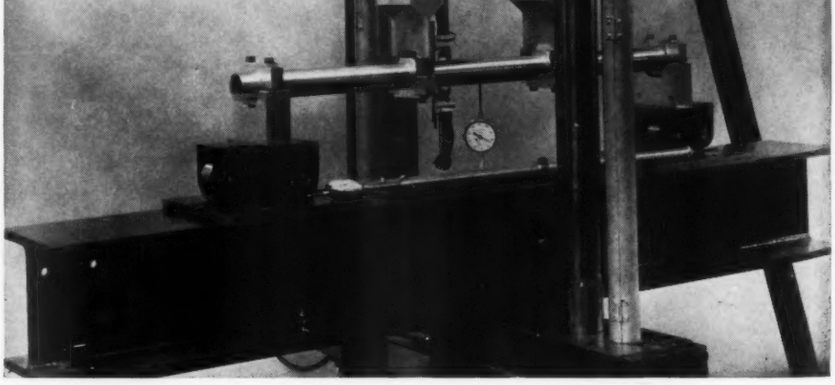


Fig. 1—Beam test with load applied at third-points of the span and at the neutral axis of the beam

greater than plus or minus 3 percent from the average value of 64,200 lb. per sq. in. They are also quite close to the tensile strength of the material; however, there was no indication of incipient tensile failure. The relatively low value obtained with the sixth-point loading on the short span is probably because of the fact that the computed maximum shearing stress in the outer sixths of the span was approximately equal to the typical shearing yield strength of the material.

The average value of 63,750 lb. per sq. in. obtained from the two tests using third-point loading is within 4 percent of the value of 61,500 lb. per sq. in. computed by the equation

$$f_B = 1.773\,S - 1.7\,\frac{S^2}{E}\,\frac{d_m}{t}$$

in which

f_B = modulus of failure, lb. per sq. in.
S = compressive yield strength, lb. per sq. in.
E = modulus of elasticity, lb. per sq. in.
d_m = mean diameter of tube wall, in.
t = thickness of tube wall, in.

This equation was developed by Dr. William R. Osgood for round tubing of aluminum alloy 17S-T and other materials having affine stress-strain curves. See W. R. Osgood, "The Crinkling Strength and Bending Strength of Round Aircraft Tubing," N.A.C.A. Report No. 632, 1938. It is based on test results in which the loads were applied on the neutral axis of the beam at the third-points and the load-points had freedom of longitudinal motion as the specimen deflected.

In view of the fact that the relation between modulus of failure and diameter-thickness ratio given in Fig. 2 is based on specified properties and the material used in these tests had properties somewhat greater than the specified values, a direct comparison with these test data cannot be made. A reduction to standard properties can be applied to the test data by reducing them in the direct ratio of the typical compressive yield strength to the actual yield strength. In the absence of compressive properties the reduction might be based on the specified and actual tensile yield strengths. When the average modulus of failure from the two tests with third-point loading is reduced by either method the agreement with the curve in Fig. 2 is within 5 percent at all points.

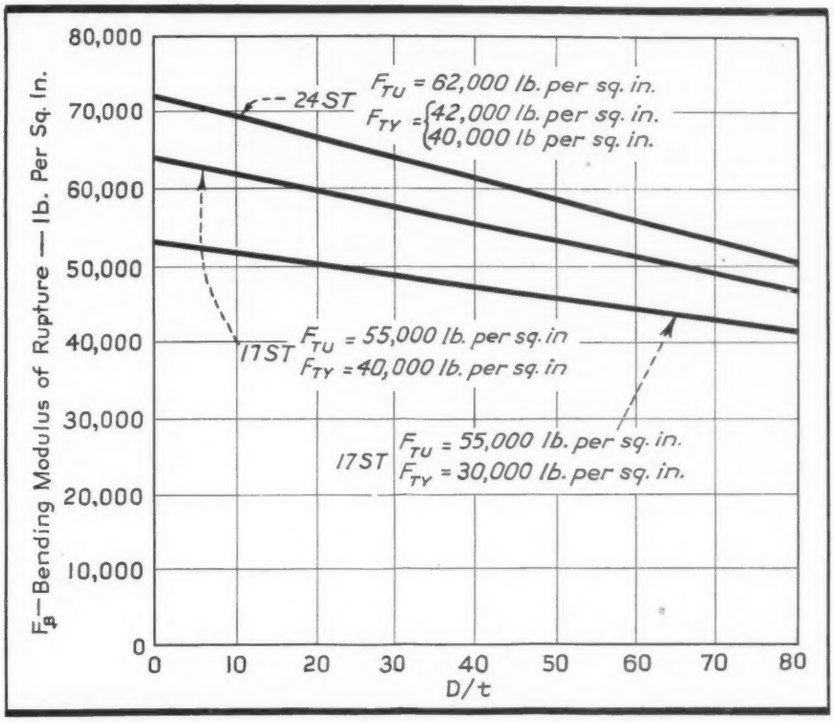


Fig. 2—Bending modulus of rupture of aluminum alloy round tubing restrained against local buckling at loading points. From ANC-5, Strength of Aircraft Elements

In these tests, strains were measured on the extreme fibers by means of type A Huggenberger Tensometers using a gage length of 1 in. The stresses obtained as the product of the measured strains and the modulus of elasticity (10,500,000 lb. per sq. in.) agree very well with the stresses computed by the ordinary beam formula. Deflections at several points along the span were measured by means of a dial gage and, in the elastic-stress range, there was good agreement with values calculated with a consideration of both the bending and shearing deflections.

From these few test data it appears that values of the modulus of failure taken from Fig. 2 agree reasonably well with the reduced test data for 17S-T round tubing loaded in such a way that a length of at least three diameters is subjected to uniform bending moment. If the loading condition is equivalent to a single concentrated load, there will be an extra margin of safety, provided the tube is supported against local damage at the points of concentrated load. Of course, the maximum shearing stresses must not exceed the shearing yield strength, which in the case of 17S-T is about 60 percent of the shear strength of the material as determined by a double-shear test.

Table 1—Results of Beam Tests on Aluminum Alloy 17S-T Round Tubing

Size of tubing: 2-in. O.D. by 0.083-in. wall

Specimen	Span		Location of Load	Maximum Load, lb.	Modulus of Failure,* lb. per sq. in.
	Diameters	Inches			
A1	10	20	Center-point	3,625	78,800
A2	10	20	Third-points	4,310	62,300
A3	10	20	Sixth-points	5,640	40,800
B1	20	40	Center-point	1,684	73,300
B2	20	40	Third-points	2,250	65,200
B3	20	40	Sixth-points	4,500	65,200

* Stress computed by the ordinary beam formula for the beam under the maximum load.

LINKAGES FOR CONVERTING

TRANSMISSION OF MECHANICAL MOVEMENTS or impulses and conversion of electrical circuit variations to mechanical motion may employ any of a wide variety of mechanical linkages as well as hydraulic, pneumatic, or electrical forces. Patent records show all of the typical devices illustrated on these two pages. While these were designed for transmission of small forces, it is obvious that the parts can be made heavier and modified to withstand heavier loads.

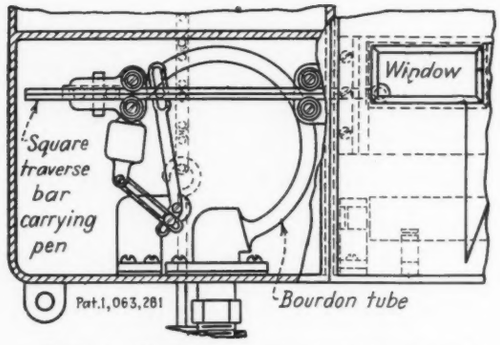


FIG. 1 – *Straight line movement produced by linkage from Bourdon tube*

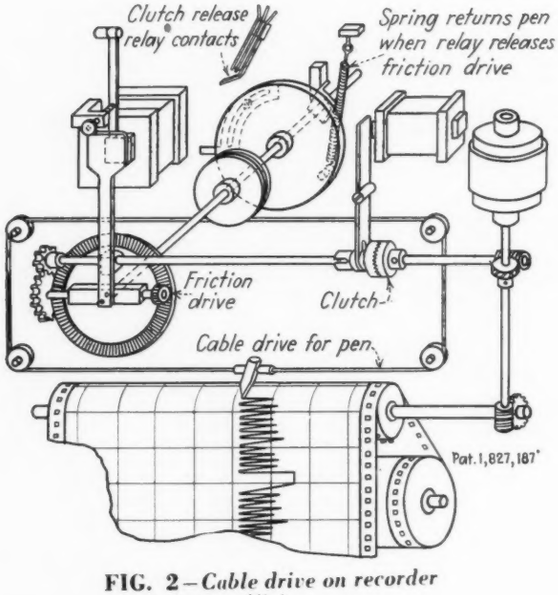


FIG. 2 – *Cable drive on recorder of workman efficiency*

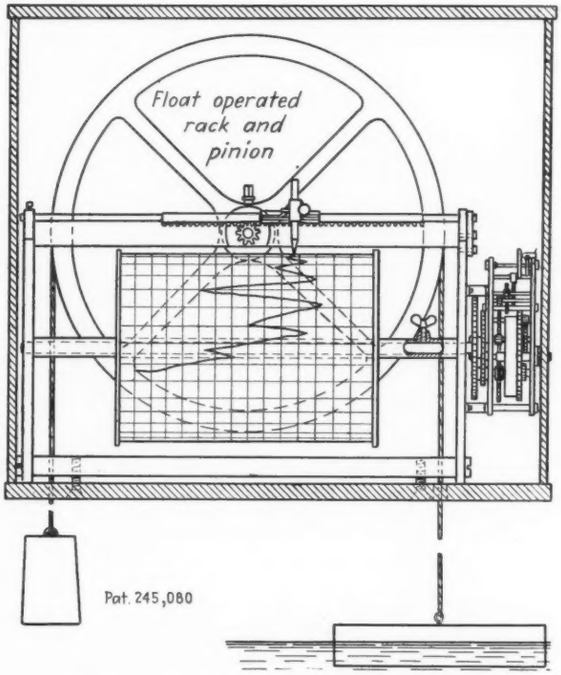
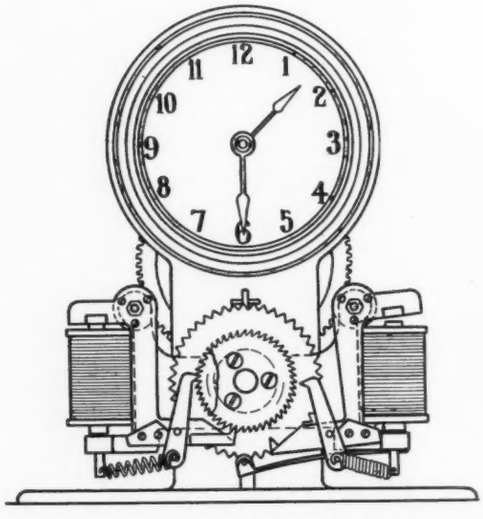


FIG. 3 – *Rack and pinion drive to pen*



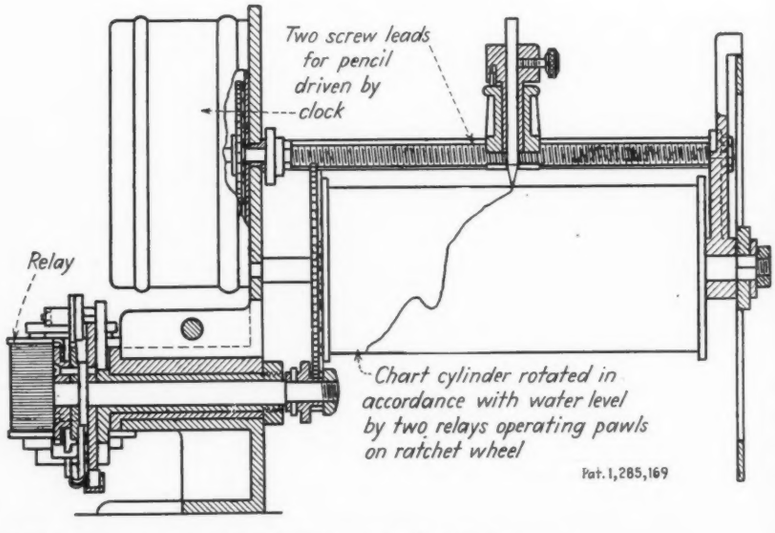

Two screw leads for pencil driven by clock
Relay
Chart cylinder rotated in accordance with water level by two relays operating pawls on ratchet wheel
Pat.1,285,169

FIG. 4 – *Variable reversing chart movement controlled by relays; clock driven pencil*

SHORT MOTIONS OR IMPULSES

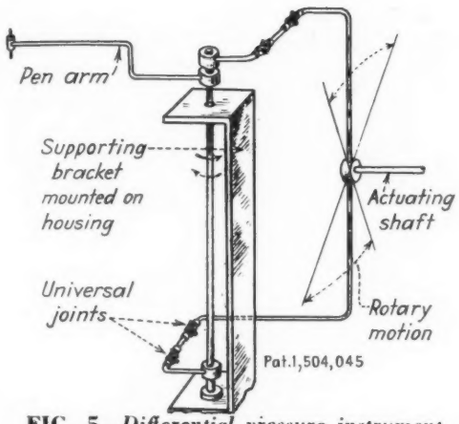


FIG. 5—*Differential pressure instrument with unique pen arm linkage*

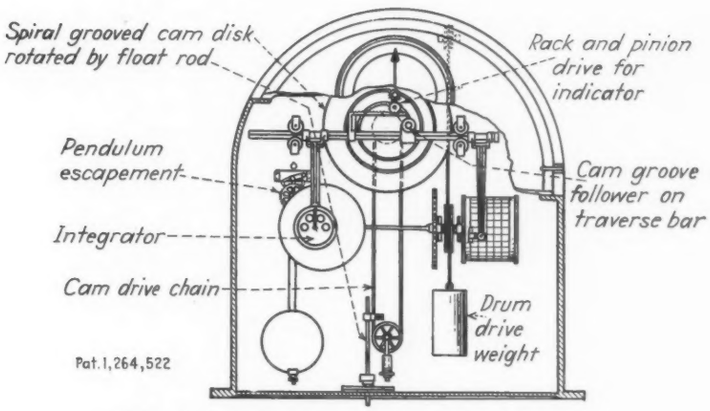


FIG. 6—*Spiral groove cam rotated by float moves pen, integrator arm, and indicator hand*

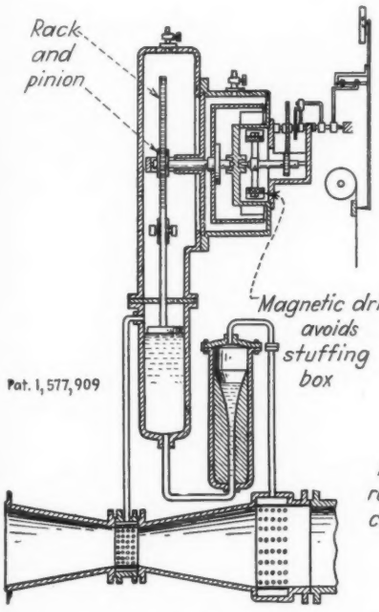


FIG. 7—*Magnetic drive from rack and pinion with straight line movement of pen*

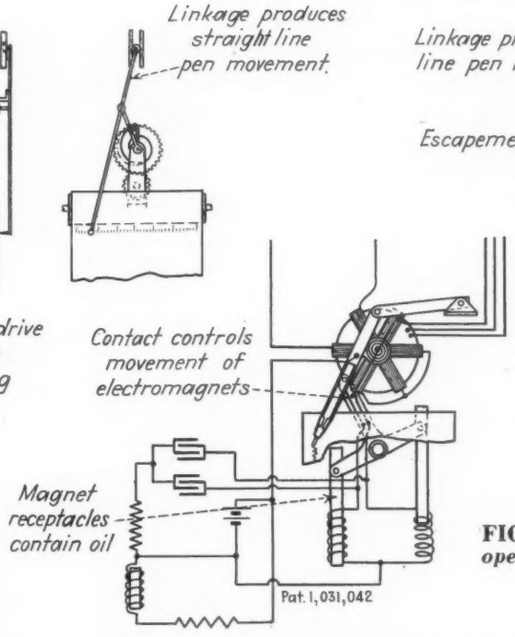

Linkage produces straight line pen movement
Contact controls movement of electromagnets
Magnet receptacles contain oil
Pat. 1,031,042

FIG. 8—*Magnetically controlled pen activated by contacts on T-arm and armature*

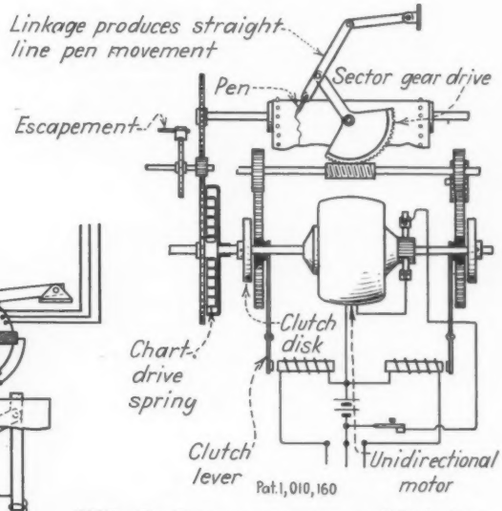
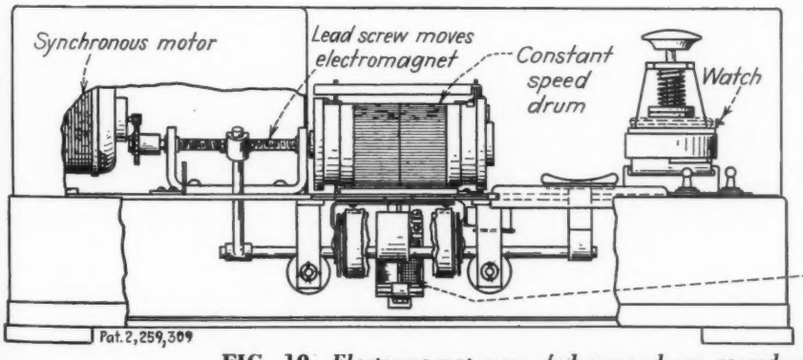


FIG. 9—*Screw, sector gear and link drive operated by electric circuit variations*



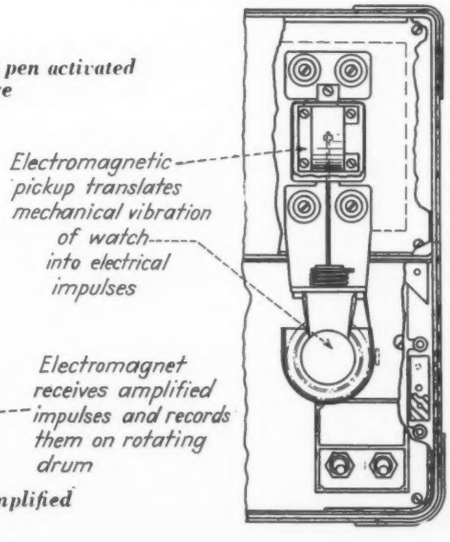

Electromagnetic pickup translates mechanical vibration of watch into electrical impulses
Electromagnet receives amplified impulses and records them on rotating drum

FIG. 10—*Electromagnet, worm fed across drum, records amplified impulses of watch ticks to check time keeping accuracy*

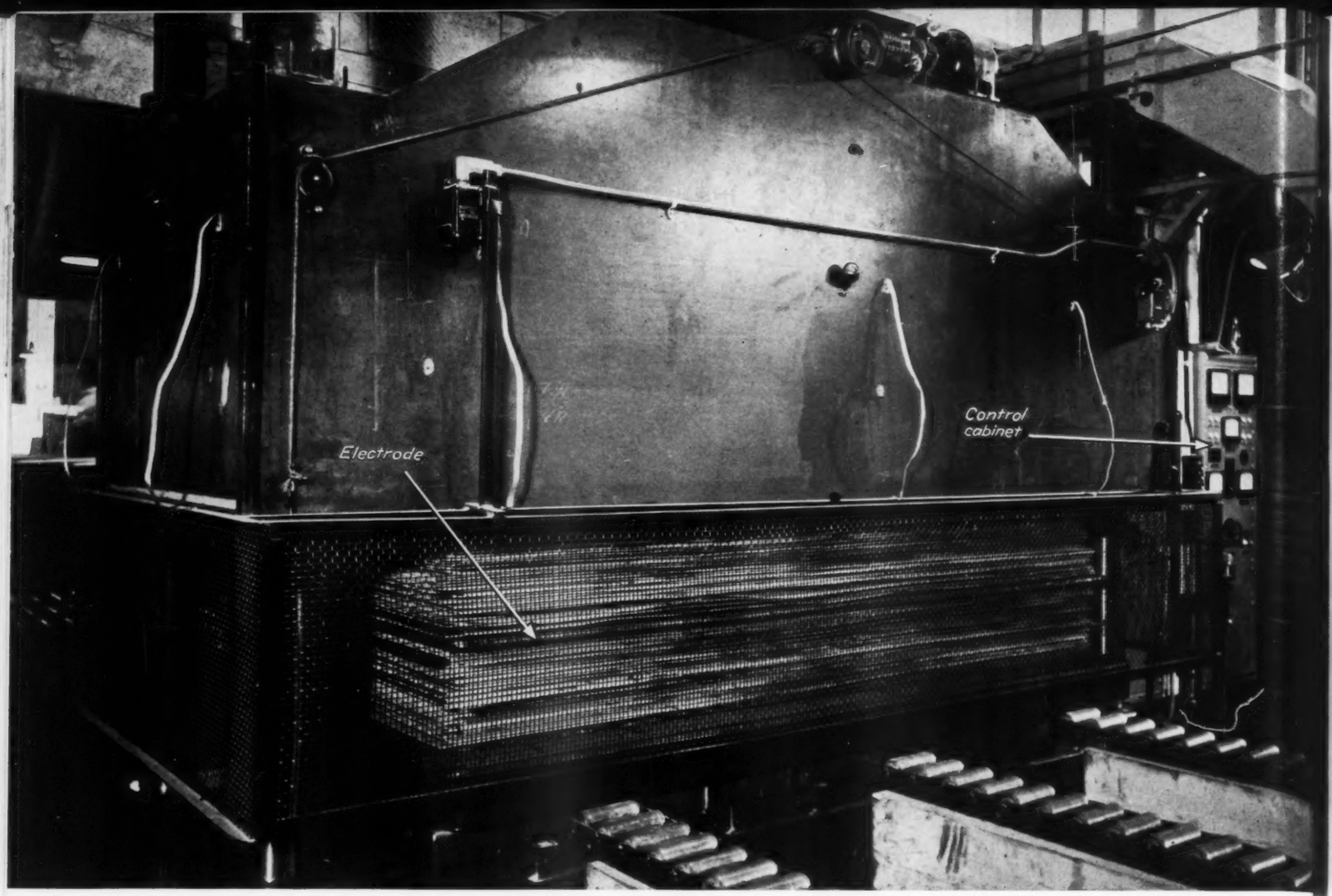


Fig. 1—Press equipped for electrostatic heating making a thick slab of resin bonded plywood. The control cabinet to the right houses all of the electrical apparatus

Electrostatic High-Frequency Heating Makes Possible Many New Designs

The description and scope of application of this new process by which electrical non-conducting materials are heated uniformly throughout is set forth in detail, as explained by Paul D. Zottu, chief engineer of the Thermex Division of the Girdler Corporation. Examples of the results obtained by this process and the method of calculating the time and energy required for a given job are included.

OPERATING on a principle entirely different from that employed in high-frequency induction heating, electrostatic heating has now paved the way for many new design possibilities. In high-frequency induction heating, the high-frequency magnetic field creates eddy currents in the metal being heated. The eddy currents are dissipated and converted into heat at or near the surface of the metal, and the higher the frequency, the shallower is the heating effects. Deeper penetration is obtained only by heat conduction through the material. Also because high-frequency induction heating depends for its operation upon the development of eddy currents, it can be applied only to metals, or more strictly speaking, electrical conductors.

Need for an electrical method for heating non-conducting materials has long been evident. Because materials that are poor conductors of electricity are also poor conductors of heat, it is necessary that any process for heating non-metals must be capable of heating the whole mass at a uniform rate throughout, if the whole mass is to be raised to the same temperature. That is, heating without a temperature gradient within the material. The desirability for such a type of heating has been most pronounced in the plastics industry.

Because of its low rate of heat conductivity, it is impossible to heat a plastic material uniformly throughout when employing the usual means of heated platens. The material near the surfaces are over-heated while the interior is still relatively cool, a condition which becomes worse as the thickness of the plastic material increases. The same difficulty is encountered in the

manufacture of laminated plywood wherein thermosetting glues of any type are used for the adhesive. Up to this time it has been uneconomical to produce sections of laminated plywood thicker than about 1 in. because of the impossibility of effectively setting the adhesive in the interior before the resin near the surfaces became over-cured.

The impossibility of uniformly heating thick sections of resin-impregnated material is accentuated by the very nature of the chemical process by which resins set. A large percent of the weight of the complete product is due to the impregnating resin. When the hot platen of the press in the conventional process comes in contact with the impregnated material, the thermosetting reaction begins. This process is exothermic, liberating heat and causing the temperature to rise over and above the temperature rise produced by the hot platen. The heat liberated, plus that received from the hot platen frequently causes overcuring of the product.

The limitations imposed by the impossibility of applying the necessary heat throughout thick sections of plastic or plywood materials has now been eliminated by the high-frequency electrostatic heating as produced on thermal equipment of the Girdler Corporation. The product being heated, which may be plywood, plastic molded parts, rayon filaments, or other non-conducting material, serves as the dielectric of a condenser. The electrodes of the condenser may be two conducting surfaces, one on either face of the material. In Fig. 2 is shown the set-up for simultaneously heating and pressing layers of plywood stacked in a press. The desired number of sheets are placed on the lower platen of the press and on top of this pile is placed an electrode or plate. The electrode consists of a piece of sheet copper or any other metal sandwiched between thin layers of plywood or other similar non-conducting material. On top of the electrode is placed another pile of plywood of equal thickness. The electrode is connected to one terminal of a high frequency transformer. The other terminal of the transformer is connected to the upper and lower platens of the press. The entire press is maintained at ground potential. A voltage of some thousands at a frequency of 1,500,000 to 10,000,000 cycles is then applied.

In installations up to 15 KVA the electrical equipment furnishing the heating energy is all contained in a cabinet which is placed wherever convenient in the vicinity of the press. As shown in Fig. 1, the cabinet may be relatively small. The apparatus in the cabinet includes switch gear, transformers, rectifiers, oscillators, power amplifier and all the necessary accessories, such as coils, condensers, etc. With the exception of an air blower, there are no rotating units or machines involved, hence maintenance is not difficult. When power is applied the heat generated is not produced by a hysteresis effect as in the high-frequency induction heating of metals, but is generated as a result of the agitation of the molecules when subjected to the high-frequency field. One explanation is that the effect of the high frequency is such as to make the molecules repeatedly change their shape. On applying the electric field a spherical molecule may be thought of as being deformed into an ellipsoid. The frequency of the applied electric field determines the number of times the molecule is deformed per second. This energy of agitation is converted into heat. Basically, the principle of operation is the same as that used by some diathermy machines, heat being generated uniformly throughout the whole mass of the material lying in the electric field. The temperature is always the same throughout.

Because the material is heated uniformly throughout, practically any thicknesses of laminated plywood can be made and all of the glue layers will be cured uniformly. As an example, 148 sheets of impregnated birch veneer have been glued by this process successfully using a phenolic resin adhesive. By test, the impregnated compressed birch block of 148 laminations was found to have a tensile strength of 45,000 lb. per sq. in. and its specific gravity was one-half of that of aluminum.

Because thick laminated sections of impregnated stock can now be produced successfully, it has been possible to develop some unusual types of laminated material. For example, by using different lengths of veneer as shown in Fig. 3 and pressing this between the upper and lower platens which remain parallel, a material of varying density is obtained as indicated in the figure. At one end of the cross-section, the material is highly dense and correspondingly stronger, and both density and strength decrease toward the other end of the cross-section as indicated This enables the design of beams of varying strength to meet certain load conditions. Such a construction also presents great possibilities for application where the member is subjected to centrifugal force. The low density material is placed near the periphery of the wheel, while the high density and stronger material is at the hub. A practical application is for aircraft propeller blades.

This process is not limited to the molding of parts such as boards and

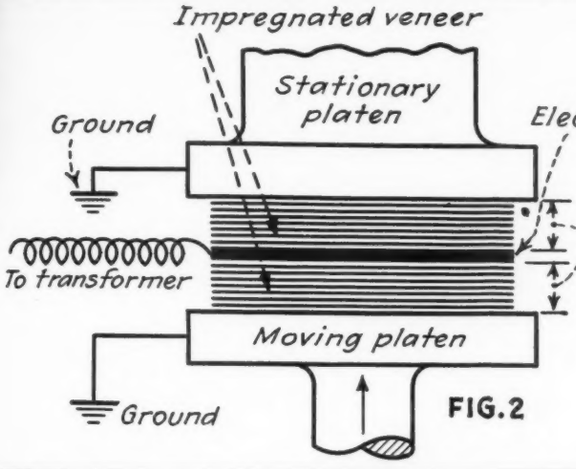


FIG.2

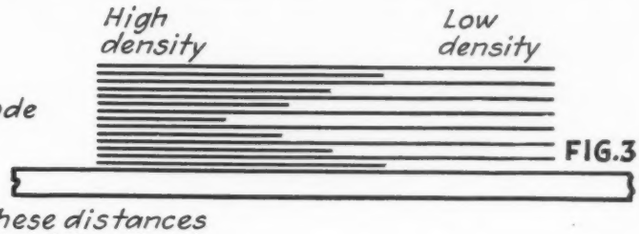


FIG.3

Fig. 2—Schematic diagram of the set-up of a press for electrostatic heating

Fig. 3—By using different lengths of veneer and pressing it between parallel upper and lower platens, a material of varying strength and density is obtained

Standard unit for high frequency electrostatic heating, ready for operation

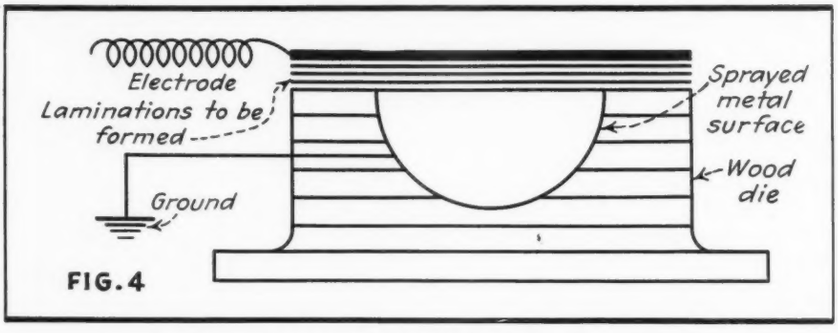


Fig. 4—Set-up for making the leading edge of an airplane wing

slabs having plane surfaces. The only basic requirement is that electrodes shall be essentially a uniform distance apart at all points. Parts having curved surfaces can readily be made if the section is of approximate uniform thickness. If a shape such as the leading edge of an airplane wing is desired, a wooden die block as shown in Fig. 4 is first constructed. The interior surface of the wooden die block is sprayed with metal and thereby serves as one of the electrodes. A corresponding male die is made. The adhesive coated plywood sheets are placed on top of the female die and a thin sheet of metal to serve as the other electrode is placed on top of the veneer. Pressure is applied, the wood sheets are forced into the female die, the electrical power is applied and in a few minutes the adhesive is cured uniformly throughout.

Typical constructions made by this process include propellers, keels for boats, thick sections of high density masonite and similar material bonded with phenolic resin. Waste fibres from rope factories are impregnated with phenolic resin and subjected to heat and pressure to form slabs, a six inch layer of fibre being reduced to a half-inch thickness. Cork granules mixed with urea or phenol resin are pressed and heated by this process to form cork boards of unusual strength, heat resistance, heat insulation. They are unaffected by moisture.

Scale models of two keels for high-speed boats were made. The one keel was made of solid wood which required a lap joint. The other was a one-piece plywood construction made by the Thermex process. The curves in Fig. 5 show the results of the tests on these constructions. It is significant that the wood construction failed in every respect, namely, by tearing apart on the tension side, buckling on the compression side, a shear failure through the wood at the connecting bolts. The plywood constructions failed by horizontal shear, indicating that in both cases the design was the optimum.

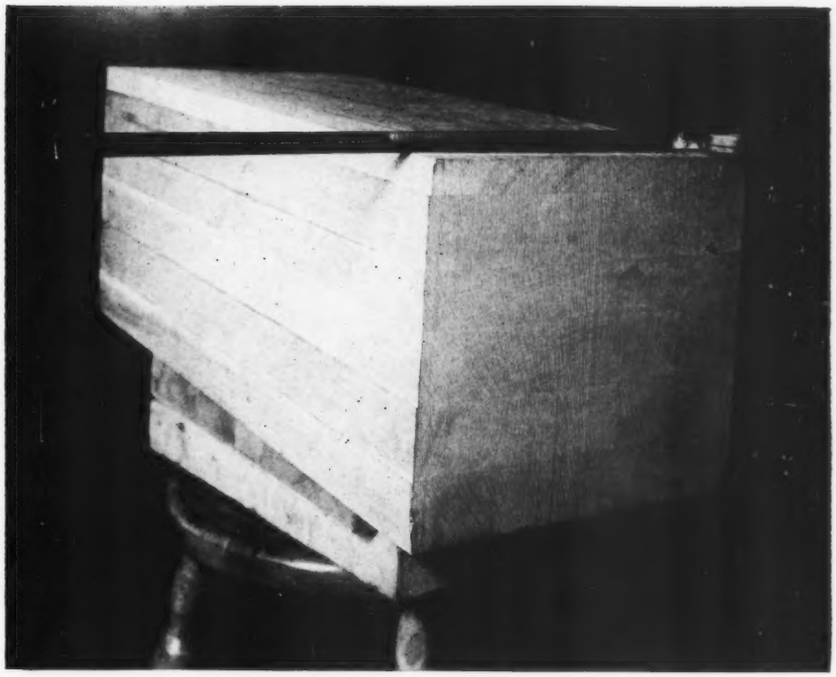
There are no critical factors involved in the electrostatic heating process and it is quite simple to calculate the time and energy requirements. It is merely necessary to know the weight and specific heat of the material to be heated and the temperature rise required. This will determine the amount of heat that must be delivered into the material. For example, if a 100 lb. block of wood is being treated and its specific heat is 0.45, it will require 45 B.t.u.'s to raise the temperature of the wood 1 deg. F. If the temperature of the wood when put in the press was 70 deg. when the current was turned on and the final temperature is to be 220 deg. F., the temperature rise will have to be 150 deg. and hence 45 B.t.u. per deg. x 150 deg., or 6,750 B.t.u. will be the amount of heat required.

If, in this operation, the power input to the heating equipment is at the rate of 25 kw and assuming an overall efficiency of the equipment is 50 percent, which is about what it is, the rate of heat generation in the wood will be 25 kw x 3,413 B.t.u. per kw. hr. x .50 or, in round numbers, 42,500 B.t.u. per hr. as generated in the wood. As the heat required to raise the temperature of the block of wood to 6,750 B.t.u., it will take about 0.16 hours, or 9.5 min. to heat the block of wood to the desired temperature of 220 deg. F. Output capacities of the units available range all the way up to 500,000 B.t.u.'s per hr. The actual capacity of equipment and

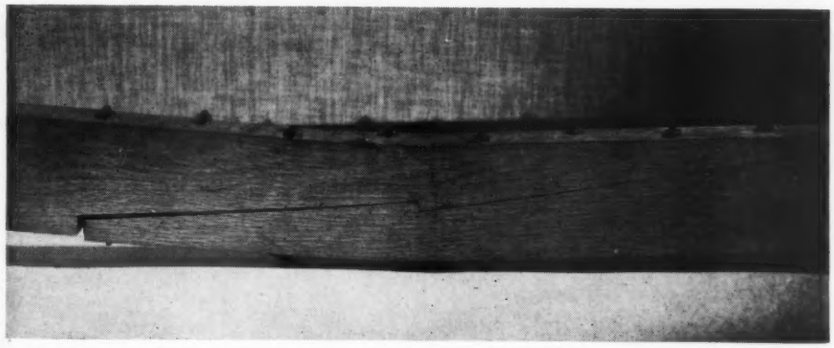
power input used is such that the whole process will be completed in a few minutes. In the above example, a 100 kw input machine would complete the whole operation in less than 2½ minutes.

Suitable instruments on the heating equipment keep the operator informed of the rate of electrical energy input and time. Controls are complete so that the operator can use any output desired up to the whole output of the machine. Effective protection and safety devices are incorporated in the equipment to insure complete protection to both the operator and electrical performance. The application of electrostatic heating is not limited to manufacture of plywood. Practically any non-metallic material can be heated in a high frequency electrostatic field. Also, the equipment can be used to produce induced heat to bring about chemical reactions of any type where heating is required.

Among the numerous advantages of electrostatic heating over conventional methods are improved quality of the product through uniform heating, less handling, speedier production, reduced labor costs, reduced glue spread, greater flexibility because of the high overall efficiency of the equipment and the ease with which adjustments in temperature control can be made, the immediate suspension of the heat when the electrical energy is shut off and thereby avoiding the danger of overheating, the absence of hot plates with their steam platens or hot water connections, and, finally, the availability of the wide range of sizes of the equipment to meet all requirements.



Block of laminated white oak bonded by electrostatic heating. It is about 10 in. square, too thick to be made by usual methods



Failed joint in solid oak keel that was loaded as a simple beam. Upper fibers crushed, lower fibers failed in tension and the wood sheared at the end bolts

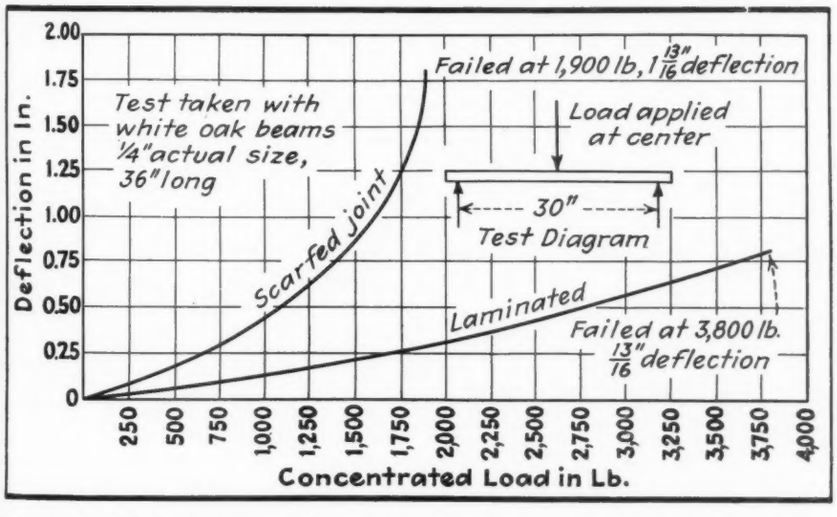


Fig. 5—Load-deflection curves of tests on two one-quarter size scale models of keels, one a white oak beam with bolted lap joint, the other a one-piece plywood construction

A table of materials that could be heated by electrostatic heating would include all types of cellulose, paper, textiles, powders, felts, leather, wools and cottons, ceramic clays, oxides, tobacco, rubber, celluloid, glass, fibre glass and granulated cork. Undoubtedly, there are many further applications which have not yet been investigated. The process can also be used for sterilizing cereals and other foods.

Among the mechanical constructions that have been made by the use of high-frequency electrostatic heating are airplane propellers, spars, ribs, wings, assemblies. Also, keels, main frames and transoms for ships.

With reference to productive capacity, two 300 kw heating units are equivalent to at least three hot plate presses, each having 15 openings and with automatic loaders. One electrostatic heating unit will easily handle the output of two modern veneer glue spreaders working continuously.

TEST SAMPLES of flexible vinyl plastic sheeting are here being clamped in place on the modified Kelly-Springfield abrasion tester. Results indicate that resistance to intermittent abrasion of the vinyls is superior to rubber and leather materials commonly used in coverings, beltings and shoe soles.

Abrasion Resistance of Flexible Vinyl Plastics

F. W. DUGGAN
Plastics Division, Carbide and Carbon Chemicals Corporation

Many applications for flexible sheet materials require good resistance to intermittent abrasion, and test results indicate that elastomeric vinyl materials are good in this property. This article presents comparative data on abrasion resistance of vinyl sheetings, rubber and leather, and describes the test methods used in obtaining the data.

FLEXIBLE plastic sheetings, in many of the uses to which they are being applied, require a certain degree of abrasion resistance for satisfactory serviceability. Binocular coverings, pneumatic pontons and windshield wipers are typical current examples. In such applications the abrasion is intermittent in character and is not of sufficient intensity to build up frictional heat which would cause the thermoplastics to flow.

To determine the comparative abrasion resistance of plasticized vinyl resins, an abrasion test incorporating these abrasion characteristics has been developed and applied to vinyl resins, rubber compounds and leather. Comparative data establish the vinyl sheetings as superior to the other materials in resistance to this type of intermittent abrasion.

Method of Test

A great deal of thought and effort has been spent on the abrasion testing of rubber by workers in that field during the past twenty years, and many different types of abrasion tests have been employed. In 1937 the American Society for Testing Materials selected six of the most widely used tests as Tentative Standards (D394-37T), and in 1940, after a three-year period of trial, adopted three of them as standard abrasion test methods for rubber. They are described in the A.S.T.M. Standards (D394-40).

Of the various abrasion tests developed for use on rubber, the Kelly-Springfield test (incorporating intermittent abrasion, with opportunity for dissipation of frictional heat) appeared most nearly suitable for use on flexible thermoplastics. Accordingly, an adaptation of the Kelly-Springfield abrader, shown on the opposite page, was developed for use in this laboratory.

In this modified Kelly-Springfield test, four test shoes, equally spaced on the circumference of the test wheel, brush the specimens against an abrasive wheel under controlled pressure as the two wheels revolve slowly in opposing rotation. The abrasive surface is a strip of abrasive paper mounted on the circumference of a split type sanding wheel. Fig. 1 illustrates the set-up. The paper is replaced every 20 min. during the one-hour test period, and the volume loss of the specimen is reported in comparison with that of the A.S.T.M. Rubber Comparison Standard *B* (D395-40). This standard will henceforth be referred to as *B* Rubber.

Several types of abrasive paper and cloth were investigated as the abrasive surface, but the one preferred in this laboratory is the "Lightning" Durundum 1W1 Norton Electrocoated Abrasive paper, grit ½ x 60, made by Behr-Manning Corporation. It is obtained on special order in 50-yd. rolls 1⅜ in. wide.

Tests were conducted on three different elastomeric vinyl compounds and four different plasticizers. For conveni-

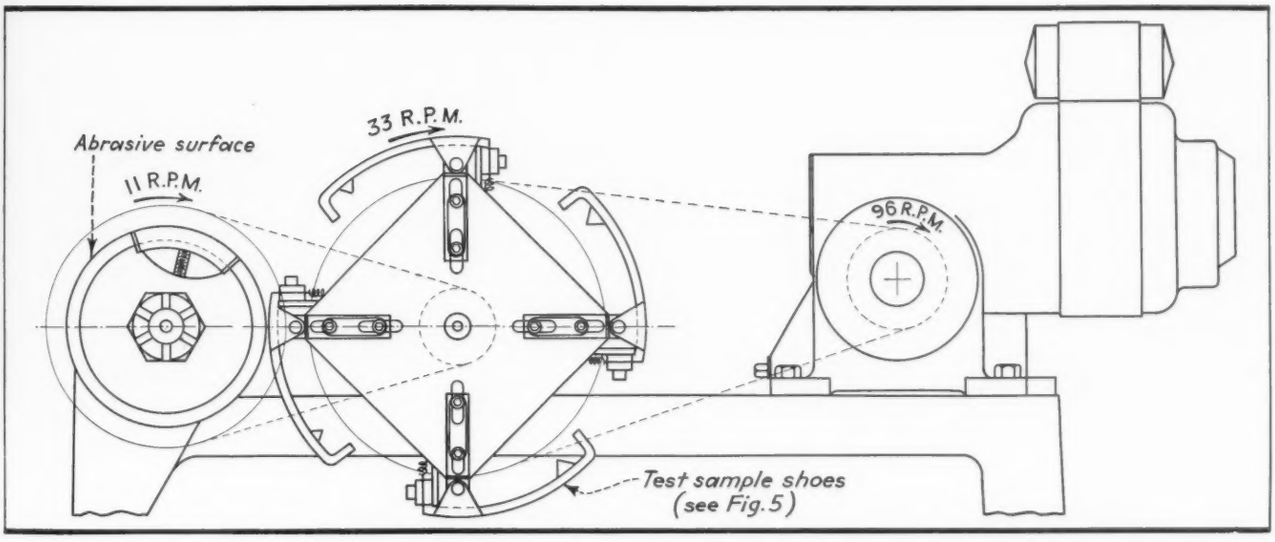


Fig. 1—In the modified Kelly-Springfield testing machine, schematically shown above, test specimens mounted on four rotating shoes are abraded by the sand-paper surfaced wheel, with time for the samples to cool off between periods of abrasion

ence in this article, these materials are designated by letters as follows:

Resin *A*—vinyl chloride-acetate copolymer, 95 percent vinyl chloride, high molecular weight. (Vinylite (VYNW)

Resin *B*—vinyl chloride-acetate copolymer, 90 percent vinyl chloride, medium molecular weight (Vinylite VYNS)

Resin *C*—polyvinyl butyral resin, high molecular weight. (Vinylite XYSG)

Plasticizer *W*—Dioctyl phthalate
Plasticizer *X*—"Flexol 3G0"
Plasticizer *Y*—"Kronisol"
Plasticizer *Z*—"Saniticizer B16"

Effects of Physical Factors

The various physical factors such as test conditions and machine adjustments which affect abrasion values are discussed in approximate order of their importance.

Constancy of Abrasive Surface. The replacing of the abrasive paper at intervals during the test was found to be the most effective method of maintaining an essentially "constant" abrasive surface. This was important for test accuracy because various test specimens "loaded" the abrasive to different extents and reduced the abrasion wear in proportion. The *B* Rubber comparison standard was one of the least objectionable in this respect, which may explain why the "loading" feature has not been too troublesome in rubber testing. The flexible thermoplastics and heavily filled rubber compounds had moderate effects, while leather and other fibrous materials loaded the abrasive very rapidly and in such a manner as to greatly reduce its abrading rate. Various methods of cleaning the abrasive surface continuously were found unsatisfactory, either because of the difficulty of removing some types of loading or because the method of cleaning altered the characteristics of the abrasive. Replacement of the abrasive paper dispensed with cleaning attachments and provided a satisfactorily constant abrasive surface throughout the course of the test.

The required frequency of replacement depends primarily on the types of materials to be tested. In this laboratory, 20-min. intervals are used for rubber and flexible thermoplastics, but 10-min. intervals are used for leather. The testing of leather is facilitated if the leather specimens occupy only two of the four test shoes, the two alternate shoes being faced with rubber which will tend to clean the abrasive.

The curves in Fig. 2 illustrate two of the points discussed: (a) The abrading rate obtained when leather is included on one or more test shoes of a series is lower, even when the abrasive paper is renewed every 10 min. (b) The 20-min. abrasive change is adequate when testing rubber or plasticized vinyl resins.

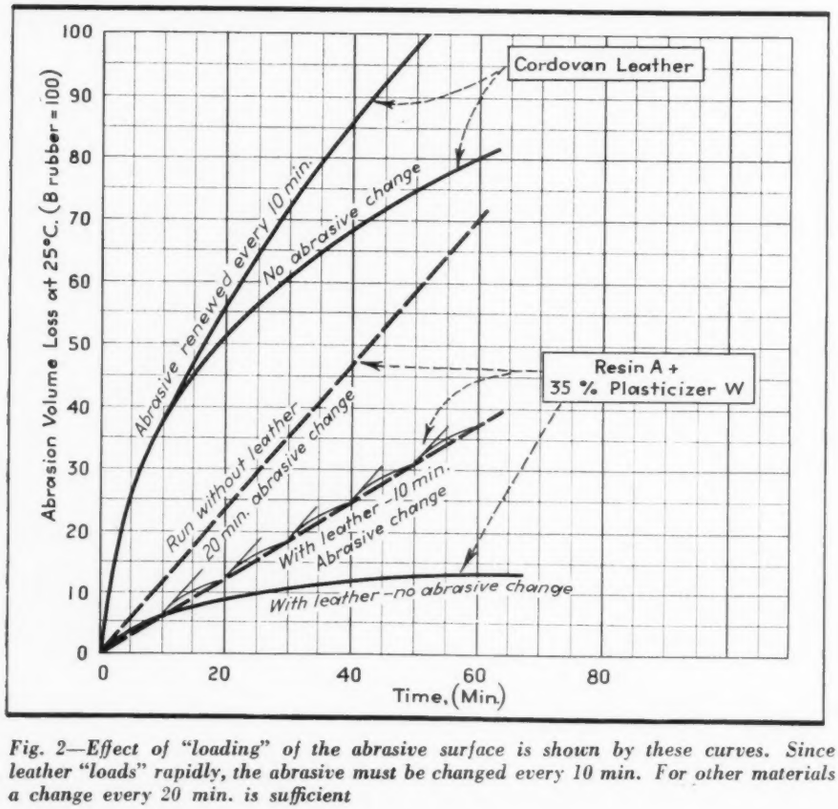


Fig. 2—Effect of "loading" of the abrasive surface is shown by these curves. Since leather "loads" rapidly, the abrasive must be changed every 10 min. For other materials a change every 20 min. is sufficient

Type of Abrasive Surface. In evaluating various abrasives, the following correlations between type of abrasive and the resulting abrasion of the test specimen were noted:

1. Different abrasives were found to abrade a given sheeting at widely different rates. Grade ½ x 60 Durundum paper produced as much wear on a flexible thermoplastic in one hour as a Norton abrasive wheel No. 1960-J produced in 20 hr. Various abrasive cloths were intermediate in abrading rate.

2. In spite of this difference in abrading rates by different abrasives, the comparative abrasion rating of a specimen relative to the value obtained on the *B* Rubber standard with the same abrasive was much the same regardless of the abrasive used. This is illustrated by the following data on Resin *A* sheetings tested under three different abrasives:

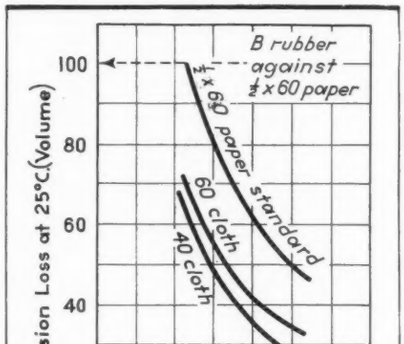


Fig. 3—As shown by these curves, abrasive cloths with coarser grits abrade specimens the least

Abrasion Loss with Different Abrasives

Resin *A* with Plasticizer	½ x 60 Paper (Standard)	60 Abrasive Cloth	40 Abrasive Cloth
20 percent *W*	110	115	112
30 percent *W*	80	84	74
35 percent *W*	70	72	63
40 percent *W*	62	64	54
50 percent *W*	50	52	46
B Rubber	100	100	100

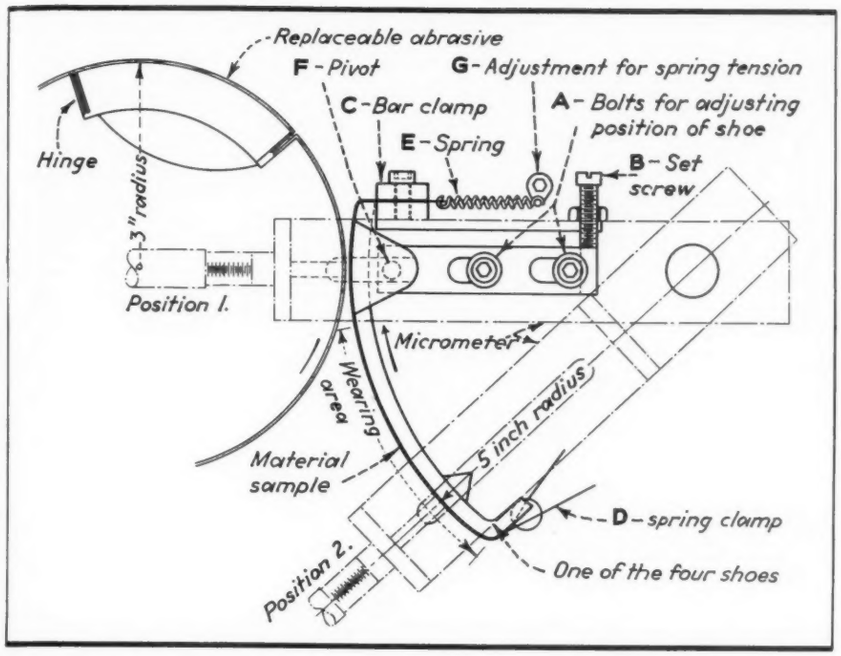


Fig. 4—To standardize abrasion clearance settings, each shoe is adjustable as shown. Clearances are accurately measured by a special micrometer

3. Comparing the abrading rates of two abrasive cloths (40 and 60 grit), the cloth surfaced with the coarser grit abraded the specimens the least. Fig. 3 shows this.

In view of the similar abrasion ratings (relative to *B* Rubber) which were obtained with different types of abrasives, the most rapid test obviously was the most desirable. On this basis the ½ x 60 "Lightning," Durundum paper was selected as the standard abrasive for this laboratory.

Abrasion Clearance Settings. In making ready for a test, each specimen is laid lengthwise on the face of a sample shoe and fastened at both ends by bar clamp *C* and spring clamp *D* shown in Fig. 4. In this position the specimen is taut but not stretched. Then the clearance between the surface of the specimen and the abrasive (at Position 1) is adjusted to 0.045 in. and fixed by means of bolts *A*. Next the surface of the specimen at Position 2 is adjusted by means of set screw *B* so that the radius from the center of the sample wheel, as measured by the special micrometer, is 0.150 in. greater at Position 2 than at Position 1. Thus, as the sample wheel rotates, the specimens clear the abrasive by 0.045 in. at Position 1 but strike the abrasive surface at a point approximately ½ in. from Position 1 toward Position 2. From this point on to the tail of the shoe, the specimen brushes against the abrasive under spring pressure. With the above settings, the wearing area on the specimen is 1⅜ in. wide (the width of the abrasive wheel) and approximately 4 in. long.

Shoe Pressure. The pressure with which the test specimen is brushed against the abrasive wheel affects the abrasion value, as would be expected. In the abrasion machine this pressure is controlled by adjusting the tension on spring *E* (by position nut *G*) so that at Position 2 it balances an 800-gram force applied radially toward the center of the sample wheel.

The increase in abrasion loss with increase in shoe pressure is illustrated by the following data taken from Fig. 5, on a flexible thermoplastic sheeting (Resin *A* + 35 percent Plasticizer *W*):

Effect of Shoe Pressure on Abrasion Loss

Shoe Pressure, grams	Abrasion Volume Loss*
700	64
800	70
900	75

*Loss for *B* Rubber at 800 grams shoe pressure = 100

Temperature. Temperature changes affect the abrasion values of various materials quite differently. In the case of rubber, abrasion losses were less at 0 deg. C. than at 25 deg. C. (room temperature). The abrasion resistances of flexible sheetings made from copolymer vinyl chloride-vinyl acetate resins (Resin *A* and Resin *B*) were affected very little by this change in temperature. On the other hand, flexible sheeting from poly-vinyl butyral (Resin *C*) had higher abrasion losses at the lower temperature.

These three different conditions are illustrated in Fig. 6 which gives abrasion losses on the three types of materials at 0 deg. C. and 25 deg. C.

Specimen Thickness. The standard specimen thickness in this laboratory is 0.040 in. In the case of the flexible thermoplastics, the thickness of the test

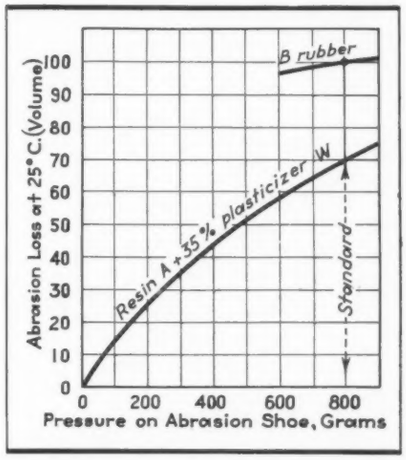


Fig. 5—Pressure with which test specimen is brushed against the abrasive wheel affects the volume of material removed. Standard pressure for these tests is 800 grams

specimen has a noticeable influence on abrasion values, thicker sheeting having lower abrasion loss. This effect is shown in the following table:

Effect of Specimen Thickness on Abrasion Loss

Resin	Plasticizer	Abrasion Volume Loss*	
		0.040 in. Sheeting	0.080 in. Sheeting
A	20 percent *W*	106	91
A	30 percent *W*	80	65
A	40 percent *W*	62	45
A	50 percent *W*	49	30

* *B* Rubber = 100

Effect of Compound Formulation

Various thermoplastic resins and plasticizers combined in the proper proportions will provide flexible sheetings which are quite similar in all outward respects. However, these sheetings may vary considerably in abrasion resistance. It is important, therefore, when selecting sheetings for uses involving

abrasive wear, to know the effects of the various components on the abrasion resistance of the sheeting.

Type of Resin. When the various vinyl resins included in this study were compared at plasticizer concentrations which provided equal flexibility, Resin *B* was found to have the lowest abrasion loss. Both Resin *A* and Resin *B* have abrasion resistance superior to *B* Rubber under this test. This is shown by the following data taken from the curves in Fig. 6:

Effect of Resin Type on Abrasion Loss

Resin	Plasticizer	Abrasion Volume Loss at 25 deg. C.
A	35 percent *W*	70
B	32 percent *W*	64
C	28 percent *X*	104
B Rubber Abrasion Standard		100

Type and Concentration of Plasticizer. As the plasticizer concentration in these vinyl resin compounds is increased, the abrasion loss decreases rapidly. This is shown in Figs. 6 and 7 from which the following illustrative data were taken:

Effect of Plasticizer Concentration on Abrasion Loss

Resin	Plasticizer	Abrasion Volume Loss at 25 deg. C.
A	20 percent *W*	106
A	30 percent *W*	80
A	40 percent *W*	62
A	50 percent *W*	50
B Rubber Abrasion Standard		100

The type of plasticizer used in the compound also has an important influence on abrasion values. Of the three plasticizers evaluated in Resin *A*, Plasticizer *Y* provided compounds having the lowest abrasion losses. The data are presented in Fig. 7. In the following table, the three plasticizers are compared at concentrations which provide equal flexibilities:

Effect of Plasticizer Type on Abrasion Loss

Resin	Plasticizer	Abrasion Volume Loss
A	35 percent *W*	70
A	33 percent *Z*	61
A	33 percent *Y*	53
B Rubber Abrasion Standard		100

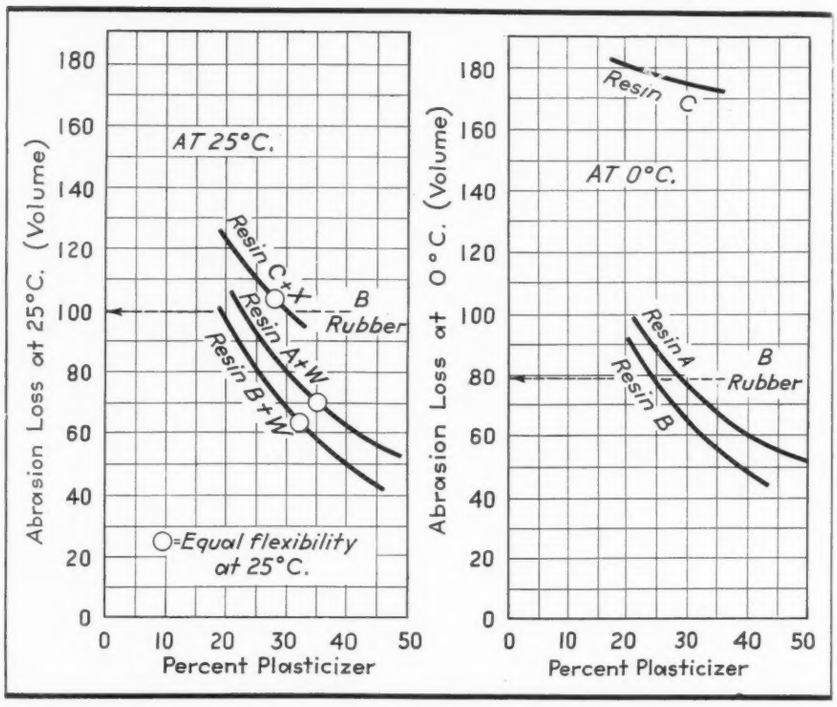


Fig. 6—These curves show the effect of temperature and plasticizer on volume of material abraded away for three different types of vinyl resins. Loss is reduced as plasticity is increased either by increase in temperature or by increase in plasticizer

Fillers. The addition of filler to a plasticized vinyl resin greatly reduces the resistance of the compound to abrasion. The extent of this degradation is shown in the graph Fig. 8 for plasticized Resin *A* with four fillers. The abrasion loss increases rapidly with increase in filler content. All compounds on the graph have a flexibility equal to that of unfilled Resin *A* + 35 percent Plasticizer *W*.

From the data on the graph it appears that the particle size of a filler determines, in part at least, the extent of degradation in abrasion value which results from the addition of the filler to the compound. The finest particle fillers (carbon black) provided the least degradation while York Whiting (the coarsest filler in the series) provided the highest abrasion loss.

Fillers increase the abrasion loss of all three vinyl resin sheetings in approximately the same proportion, as is shown on the graph Fig. 9.

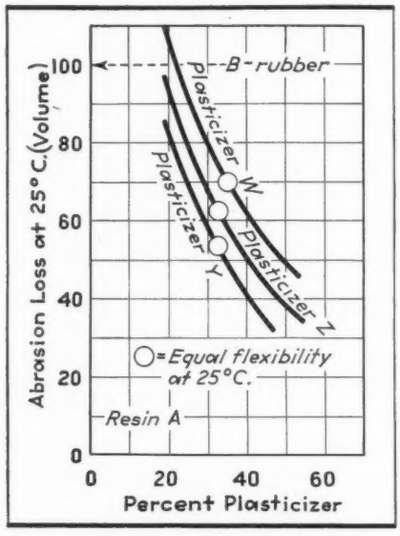


Fig. 7—Choice of plasticizer has considerable effect upon abrasion resistance of vinyl chloride-acetate copolymers, as these tests on Resin A indicate

Abrasion Data on Rubber and Leather

Abrasion values on various rubber and leather materials provide interesting comparisons with the data on the flexible vinyl compounds. In general, the plasticized vinyl resins have the lowest abrasion losses, the rubber materials abrade at somewhat higher rates, and the various types of leather at still higher rates.

Only a few types of rubber, synthetic rubber and leather were available for test, and it is not known that the samples obtained were representative of their particular types. However, the data provide a general idea of the relative abrasion resistance of the various types of materials.

Synthetic Rubber Beltings. The following table compares the resistance of natural and synthetic rubber to intermittent, low-speed abrasion. The comparison is amplified in Fig. 8.

Abrasion Loss Data on Beltings

Material	Durometer Hardness	Abrasion Volume Loss
Neoprene Belting	63	150
Prenite Belting	70	210
Ameripol Belting	69	85
B Rubber Abrasion Standard	66	100
Resin *A* + 35 percent Plasticizer *W*	74	70

Shoe Sole Materials. Both rubber and leather soling materials were tested. In considering these comparative data it should be remembered that rubber and flexible thermoplastics do not "load" the abrasive objectionably and therefore the abrasion values on these materials are quite readily reproducible. Leather, on the other hand, loads the abrasive rapidly. In an effort to compensate for this, the abrasives were replaced every 10 min. during tests on leather, and the data were corrected in comparison with the abrasion loss on a standard vinyl compound which occupied one test shoe in each series. The data are satisfactory, but should be regarded only as approximate.

Abrasion Loss Data on Solings

Material	Durometer Hardness	Abrasion Volume Loss
Leather Sole—Grain Side		750
Leather Sole—Flesh Side		1,200
Rubber Soling (Low Quality)	73	270
Rubber Soling (Uskide)	77	165
Neolite Sole	68	210
Royal Cord Sole		150
B Rubber Abrasion Standard	66	100
Resin *A* + 35 percent Plasticizer *W*	74	70

Abrasion Loss for Leathers

Material	Specific Gravity	Abrasion Volume Loss
Tipping Leathers		
Shell Cordovan *A*	0.95	220
Shell Cordovan *B*	0.96	200
Sharkskin	0.85	290
Upper Leathers		
Forest Calf	0.70	380
Woodland Calf	0.71	320
A-Grade Hide	0.82	230
Buck	0.63	750
B Rubber Abrasion Standard	1.17	100
Resin *A* + 35 percent Plasticizer *W*	1.22	70

Leathers. The abrasion data on leathers are interesting because of the wide-spread use of leather in industrial applications in which the leather is subject to occasional, low intensity abrasion. Although they are only approximate, it is probable that the values provide a fair comparison between the different types of leather.

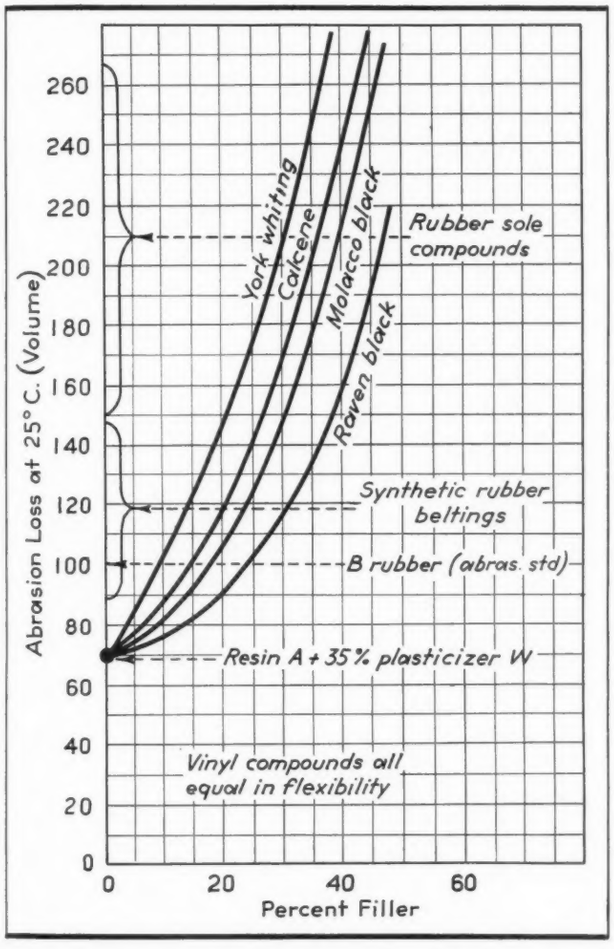


Fig. 8—Addition of a filler to flexible vinyl sheetings greatly reduces the resistance to abrasion. Finer filler particles produce less degradation than do coarse fillers

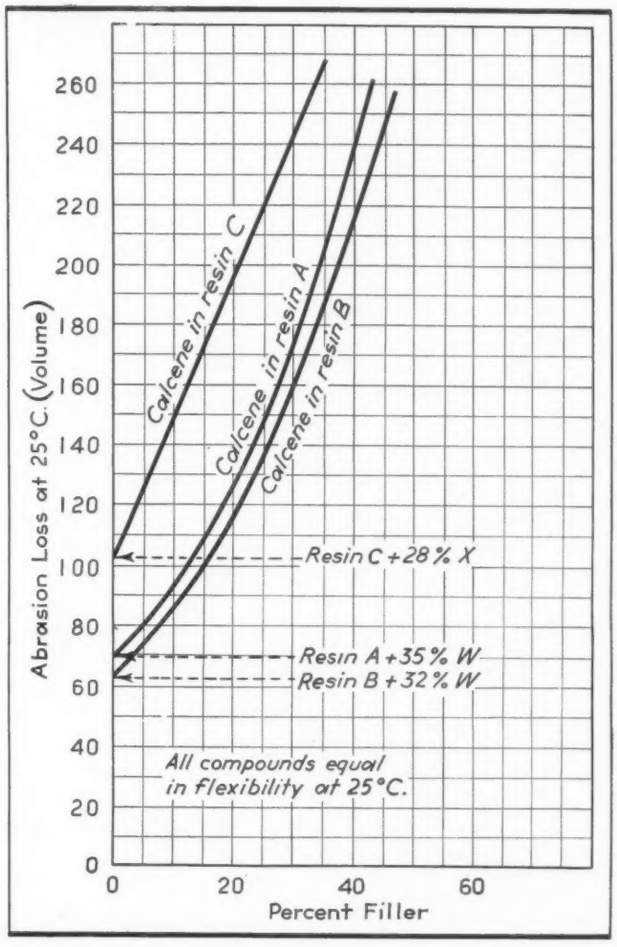

Abrasion Loss at 25°C. (Volume)
Percent Filler
Calcene in resin C
Calcene in resin A
Calcene in resin B
Resin C + 28% X
Resin A + 35% W
Resin B + 32% W
All compounds equal in flexibility at 25°C.

Fig. 9—Tests of various resins, all with same filler, show that one type of filler decreases abrasion resistance of all vinyl resin sheetings in approximately same proportion

Industry and Societies

NEWS · READER LETTERS · MEETINGS

Fabrication of Magnesium Structures Is Possible With New Welding Process

ARC WELDING of magnesium sheets, extrusions and tubings into structures simpler, lighter and stiffer than is possible in conventional duralumin construction is made possible by the "Heliarc" process developed by Northrop Aircraft, Inc. This new method of arc welding makes possible the use of magnesium as a primary construction material for airplanes, instead of limiting it to engine parts, wheels and accessories.

Contrary to popular belief, magnesium alloys are not inflammable when properly processed; in fact, they are more resistant to direct flame than aluminum alloys. Although magnesium alloys are 35 percent lighter than aluminum alloys, and 21 percent of the weight of steel per unit volume, their weight-strength ratio is comparable to aluminum alloys and they possess the design properties of stiffness and rigidity that cannot be found in other alloys. These properties, combined with the rapid production method of attachment and aerodynamic advantages presented by the "Heliarc" process, should enhance the future use of magnesium alloys for the fabrication of structures.

In "Heliarc" welding of magnesium a tungsten electrode is used with reverse polarity, making the magnesium the anode. For ferrous and copper alloys, a carbon electrode is used, and the welded structure is the cathode. Rods of the same alloy as parent metal are usually used for casting and wrought alloys. In this process a shield of helium gas envelopes the molten metal. Because helium is an inert gas it prevents oxidation and eliminates the use of a flux and the danger of entrapped flux in the weld ingots that would promote corrosion.

The arc is produced directly between a tungsten electrode and the base metal rather than between two tungsten electrodes, as in atomic-hydrogen welding. The Northrop "Heliarc" welding torch is equipped with a helium valve that is opened just prior to the striking of the arc. This valve feeds helium through the torch to the weld. Best results are obtained by feeding the filler rod into the tungsten electrode which melts off portions of the rod, thereby casting a uniform weld ingot.

A conventional arc-welding machine with d.c. generator having a 150-amp. output is desirable. However, higher output machines which operate at less than 300 amp. may be used providing lower amperage may be obtained. An upright machine is preferable in that it is easier to attach a helium tank to such a unit. Separate amperage and voltage regulators must be provided and the machine should have a continuous sequence of five increments of current control. Fairly pure helium gas is required.

Machine Parts to Have Lubricant Color Code

WORK IS ALREADY UNDER WAY by the American Standards Association on a standard color code for lubricants of machine parts. This is a war emergency project undertaken at the request of the War Production Board and the National Machine Tool Builders Association. The purpose of this standard will be to indicate by color the grade of grease or oil to be used in a given part of a machine. Standard color markings will be shown on the machine parts to be lubricated and on the container of the lubricants required for these parts.

Simple Centrifuge Improves Castings

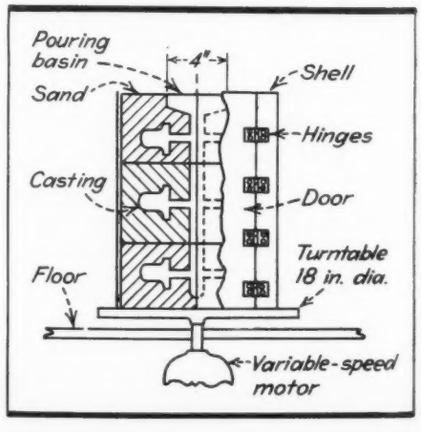
SMALL CENTRIFUGAL STEEL CASTINGS having the important advantage of uniform physical properties are being produced for Vega Airplane Company using sand molds in the simple equipment illustrated. Closer dimensional tolerances and improved surface appearance are also obtained. In general, tensile strengths 10 to 20 percent greater than in ordinary castings may be expected. Hardness remains about the same except on alloys affected by chill action, and elongation may drop slightly.

Size of castings is limited by the size of the shell. In the equipment illustrated, castings may be 16 to 18 in. long. When castings are small, each mold may consist of a series of molds similar to a metal plate and there may be tiers of 2, 3, 4 or 5 molds within one shell. As many as 20 to 50 castings may be produced from one pour.

General dimensional tolerances of $\pm\frac{1}{32}$ in. can be used on cast dimensions. It is claimed that web thicknesses of $\frac{1}{16}$ in. can be cast providing there are no large sections adjoining. However, as a general practice $\frac{1}{8}$-in. minimum is recommended for Vega parts. Draft angles, generally, are the same as for other types of sand castings.

Cost is little greater than for ordinary sand castings in the quantities used by Vega. While only various modifications of SAE 4130 steel are cast by Vega, other materials such as aluminum bronze and like alloys are being cast elsewhere with excellent results and to much greater overall dimensions using metal molds.

Ordinary rammed sand molds are used but are faced with a special sand to withstand centrifugal forces produced by speeds of 800 to 1,500 r.p.m.



Finished drawings can be produced 10 percent faster with infra-red drying lamps, such as this Westinghouse 250 watt R-40 bulb reflector drying unit. After tracing over a pencil drawing with ink the infra-red lamp is turned on the drawing for about one minute. This removes all moisture from the ink and paper so that after the pencil marks are erased the ink lines remain sharp.

Patterns are conventional types and cores are the ordinary baked type, usually arranged so that they may be pulled readily from the outer surface. The method is still in the development stage and there are some problems still to be solved.

Exchange of Data Speeds Output of Aircraft Engines

INTERCHANGE OF DESIGN and production information, experience and data has facilitated and helped to increase production of the Wasp line of air-cooled aircraft engines under the "know-how" plan developed by the Pratt & Whitney Division of the United Aircraft Corporation.

Design and production experience gained by Pratt & Whitney over the years has been passed on to Ford, Buick, Chevrolet, Nash-Kelvinator, Jacobs and Continental, who are licensed to make the Wasp line. Key men from these licensees were taken into the Pratt & Whitney main plant and placed alongside the regular employees in the production line. This has resulted in the quickest possible training of the licensees' personnel.

On the other hand, experience of the licensees has resulted in improvements which have been helpful to the Pratt & Whitney organization. So the arrangement has been mutually beneficial.

Another feature of the plan is the interchange of tools and parts. When a licensee's supply of a certain engine part has become dangerously low, or a particular tool or machine has been needed to keep up production rates, Pratt & Whitney has supplied the necessary item, providing such action would not slow down production in its own plant. Reciprocation by the licensees in this manner has also helped to keep up production at the Pratt & Whitney plant.

Still other benefits have been gained by Pratt & Whitney sending samples of such items as bearings, castings and forgings, to licensees to enable them to get into production faster.

Woody Fibers and Resin Comprise New Plastic

VEGETABLE FIBERS are combined with a resin produced by the Hercules Powder Company from Southern pine trees to form a new plastic composition called "Fedralite," developed by the Patent & Licensing Corporation, a Flintkote Company subsidiary, which is granting licenses to manufacturers who wish to use the material in their operations. The Federal Electric Company is now making 3-in. pipe "shot-hole casing" of the material as a substitute for steel pipe in oil field exploration work.

In manufacturing, the resin-treated fiber is turned out in sheets on standard paper-making machinery. These sheets are hydraulically pressed together to make compositions which are hard, dense and stiff, but not brittle. The resulting material is sturdy, but light in weight and has low water absorption. Raw stock is compressed at 800 to 1,500 lb. per sq.in. between steam-heated hydraulic platens and cured at 275 to 350 deg. F. for 4 to 6 min. and then cooled rapidly. The compression ratio is 2.0 to 2.5. Special finishes may be provided which will permit press curing at as low as 300 lb. per sq.in.

Physical and chemical properties and other characteristics of Federalite "C" stock include specific gravity, 1.3 to 1.4; specific volume, 19 to 20 cu.in. per lb.; tensile strength, 7,000 to 9,000 lb. per sq.in.; modulus of elasticity, 1,370,000; compressive strength, 31,000 lb. per sq.in.; flexural strength, 12,000 to 17,000 lb. per sq.in.; resistance to heat, 180 deg. F. continuous; softening point, 225 deg. F.; dielectric strength, short time, $\frac{1}{8}$ in. thickness sample, 350 volts per mil; effect of age, no change indoors; effect of sunlight, surface and edge resistance reduced; effect of weak acids, very slight; effect of weak and strong alkalies, decomposes; effect of organic solvents, none on hydrocarbons; clarity, opaque; color possibilities, limited, except with base sheets; machining quality, fair to good; nails readily;

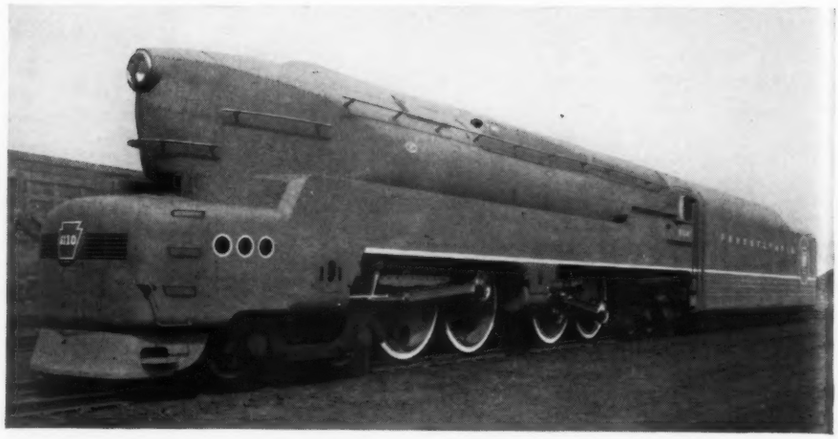
machineability, similar to phenol plastic; paintability, satisfactory with high quality force-dry paint or normal paint over shellac primer.

Joshua Hendy Absorbs Crocker-Wheeler Concern

LARGE-SCALE MANUFACTURE of electrical equipment, particularly d.c. apparatus, becomes a reality for the first time west of the Mississippi River with the recent acquisition of the Crocker-Wheeler Electrical Manufacturing Company, Ampere, N. J., by the Joshua Hendy Iron Works, Sunnyvale, Calif.

Plans for the combined operation include expansion of the Crocker-Wheeler properties in New Jersey and the Hendy properties in California, as well as the manufacture of electrical apparatus at the Hendy plant at Sunnyvale, Calif., where executive control of the combine will center. In addition to certain war material, Crocker-Wheeler standard products include polyphase induction motors, synchronous motors, d.c. motors, a.c. and d.c. generators and motor-generator sets.

The Hendy organization is described as the country's leading producer of marine engines for Liberty ships. In addition, the company is going into the production of turbines.



Studies made by Baldwin Locomotive Works and Pennsylvania Railroad engineers starting several years ago have resulted in this 4-4-4-4 design of locomotive, for high-speed passenger service on the Pennsylvania Railroad between Harrisburg and Chicago. Speed rating is 100 m.p.h. with a load of 880 tons, signifying that this unit is capable of handling a heavy passenger train without double-heading of locomotives. Two of these units are now in service. They are designed to do the same work west of Harrisburg that the type GG-1 Pennsylvania electric locomotives do on the electrified divisions east of Harrisburg. Thus, the necessity for using two steam locomotives on trains that are hauled by a single electric locomotive is eliminated. High speed in these units is obtained primarily by making available extra steam capacity at high speeds with reduced piston load, lighter machinery parts and lower piston speed. Poppet valves, unusual in locomotives, are provided. Working pressure is 300 lb. and cylinder size is 19¾ x 26 in. Raymond Loewy, industrial designer, did the styling. General characteristics are similar to the 6-4-4-6 locomotive displayed at the New York World's Fair, with the important advantage that these units can be operated over any part of the main line territory of the Pennsylvania system.

Ends of high-power radio transmitting tubes are sealed at the Westinghouse Lamp Division with this "cannon burner." As the big tube rotates on a lathe the gas flame of more than 1,000 deg. F. melts the end of the glass bulb to make an air-tight seal. The tubes are used in war communications.

Electron Microscope Focuses Electrostatically

ELECTROSTATIC instead of electromagnetic focusing of the beam of electrons features a new electron microscope that is mobile, small and operates on ordinary house current. This device, announced by engineers of the General Electric Electronics Laboratory, is capable of producing images 10,000 times the size of the subject.

The electron beam passes through the specimen inside a vacuum chamber and produces a visible picture on the fluorescent viewing screen. This image can then be photographed outside the tube and, if desired, enlarged many thousand times the original size of the specimen to make a wall print known as an "Electronmicrograph." Electrostatic fields guide the path of electron waves through the instrument, acting in this manner as electronic lenses.

It is claimed that this electrostatic principle can be developed far beyond its present use, and may eventually lead to such attainments in microscopy that man will be able to see and study for the first time the structure and hidden forces of atoms.

Discussions and Comments from Readers

MONROE DEFENDS STEVENS' SOLUTION OF PROBLEM

To the Editor:

May I comment on the two articles by Herbert H. Stevens, Jr., in the July and August issues of PRODUCT ENGINEERING on the subject of measuring angles between lines and planes in space, and the comments of William H. Rasche and Frederick G. Wilde in the October issue?

Mr. Stevens' method is more complicated in the case of measuring a single angle between two lines in space, as Mr. Rasche and Mr. Wilde point out, but Mr. Stevens' method is designed for measuring a great many angles, not only between lines but between planes in a complicated space structure, and his method of a direction diagram to show in a single view the direction of every one of these elements is a useful and time-saving method.

It is also more accurate in practice by reducing cumulative errors in using the drafting equipment. The complete picture of all angles between lines and planes are in one view, and this diagram has been produced through one transference of points from two views. The points in the diagram are not transferred again in measuring any of the angles.

The relative direction in space is more readily visualized from this single diagram than from two or more orthographic views, and thereby reduces interpretation mistakes by the draftsman.

I am acquainted with Mr. Stevens and have used his method for over two years in designing and laying out bent tubular structures for the aircraft seating manufactured by the Warren McArthur Corporation.—CLEAVELAND D. MONROE
Warren McArthur Corporation

RECESSED-HEAD SCREWS STANDARD FOR AIRCRAFT

In the cartoon entitled "Engineers!! All-out Defense Means Out With All Non-Standard Parts!", published in PRODUCT ENGINEERING for October, page 583, recessed-head screws were shown in such a manner as to imply that they were not standard for use in aircraft. Several readers have questioned this point, stating that they knew that millions of such screws are used by the aircraft industry. That is correct, as is indicated by the following excerpt from a letter from the National Aircraft Standards Committee:

"The conclusion which may be drawn from this cartoon is not entirely correct. I am sure that there was no intention on the part of the artist to imply that recessed-head screws as such are non-standard in the aircraft industry. In fact, the N.A.S.C. has recently developed a series of standard screws with both the Phillips and the Reed & Prentice recesses. Screws may be non-standard when any of several considerations, such as thread type, length, head shape, material, countersink angle, etc., vary."

Activities Among Technical Societies

ENGINEERING CURRICULA ACCREDITED AT 14 SCHOOLS

Engineering curricula in 14 universities and colleges have been recently accredited by the Engineers Council for Professional Development. These include aeronautical, civil, electrical, mechanical and metallurgical engineering at the University of Notre Dame; general engineering at the University of Toledo; chemical engineering at Bucknell University, Cooper Union Night School of Engineering, University of Florida, University of Maryland, Northeastern University, Oregon State College, and Worcester Polytechnic Institute; mechanical engineering at Catholic University of America; ceramic engineering at Georgia School of Technology; geological engineering at the University of Idaho; aeronautical engineering at the Agricultural & Mechanical College of Texas; and civil, electrical and mechanical engineering at the University of Southern California (Los Angeles).

FRITZ MEDAL GOES TO DR W. R. WHITNEY

Dr. Willis Rodney Whitney, director-emeritus of the General Electric Research Laboratories and non-resident professor of chemical research for the Massachusetts Institute of Technology, is the recipient of the John Fritz medal for 1942 for "distinguished research" and for "coordinating pure science with the service of society through industry."

DR. H. L. DRYDEN HEADS AERONAUTICAL INSTITUTE

Dr. Hugh L. Dryden, of the National Bureau of Standards, has been elected president of the Institute of Aeronautical Science for 1943. He is the eleventh president of the Institute and succeeds Hall L. Hibbard, vice-president and chief engineer of the Lockheed Aircraft Corporation. Dr. Dryden is chief of the mechanics and sound division of the National Bureau of Standards. He has been concerned chiefly with fundamental research in aerodynamics and hydrodynamics and has supervised the Bureau's research on aircraft structures and instruments.

Meetings

American Institute of Electrical Engineers—Winter convention, Jan. 25-29, New York, N. Y., Engineering Societies Building.

American Society of Heating & Ventilating Engineers—49th annual meeting, Jan. 25-27, Cincinnati, Ohio, Hotel Gibson.

American Institute of Mining & Metallurgical Engineers—Annual meeting. Feb. 14-18, New York, N. Y.

American Society for Testing Materials—Spring meeting and convention, week of March 1, Buffalo, N. Y.

Do You Know That—

Over 500,000 lb. of aluminum have been saved by the General Electric Company in the manufacture of street lighting, searchlights, floodlights and other similar equipment by replacing the aluminum reflectors with silvered-glass reflectors consisting of metal casings with the silver baked between a layer of glass and a layer of porcelain enamel. (1)

DEVELOPMENT of a new fluorescent material not susceptible to moisture has been announced. A paint film is prefabricated in the form of a tape or a sheet and laminated under heat and pressure so that there is a transparent plastic film on each side. The material can be excited by daylight or a flood lamp in 20 sec. and the glow lasts for 24 hr. (2)

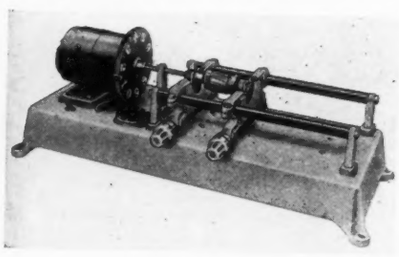
RUBBER for army raincoats is being replaced with a new synthetic called Haydenite, produced by Stanley Chemical Company. This material may also replace rubber in other products using waterproof fabrics. (3)

FROM ORDINARY CATTAIL FIBER a fluffy, water-resistant down is being produced which can be used as stuffing for upholstery, life preservers, sporting goods, toys and other padding purposes. (4)

New Materials and Parts

Balancing Machine Indicates Excessive Vibration

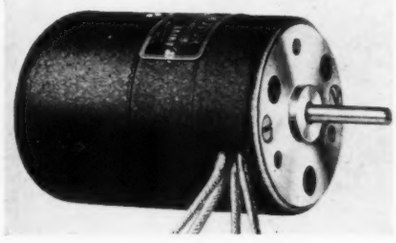
Noise and premature wear resulting from excessive vibration of rotating parts caused by couple action may be eliminated with "Dy-Namic" balancing machines. A new balancing principle, extremely sensitive and accurate, makes possible a low-cost and easy-to-operate machine. The disturbing centrifugal force or force-couple is indicated with a high degree of accuracy. Both the



angular position and the value or amount of unbalance is shown at the same time. The machine indicates whether a static or dynamic unbalance, or both, are present without reversing the ends of the body being balanced. Available is a variety of models ranging from bench units to large floor and pit-type machines weighing from 6 oz. to 1,000 lb. Bear Mfg. Co., Industrial Div., Rock Island, Ill.

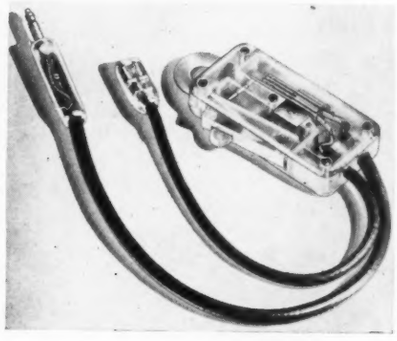
Aerial Camera Motor Is Rated at 1/120 Hp.

Ball bearings are a feature of a fractional horsepower motor designed for aerial camera work. It is rated at 1/120 hp. and operates on 12 volts. The motor has a speed of 6,000 r.p.m., weighs 14 oz. and has an overall length, not including the shaft, of $3\frac{3}{32}$ in. The shaft extension is 1 in. and the shaft diameter is 0.1875 in. The diameter of the housing is $2\frac{3}{16}$ in. Signal Electric Mfg. Co., Menominee, Mich.



Switch Can Be Operated While Wearing Heavy Gloves

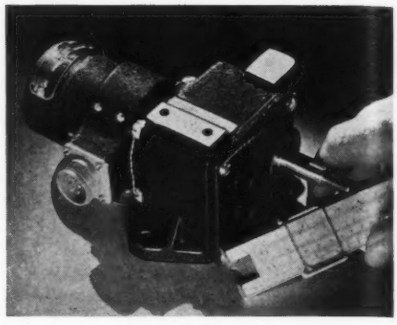
Used primarily by aircraft radio operators is the SW-141 Phone-Switch. It is a double circuit microphone switch designed for use by an operator wearing heavy mittens and so constructed as to permit easy on-and-off switching. Normally, it remains in the open position but can be locked in the closed



position. High impact strength Tenite II is used in the construction. The switch is mounted on brass brackets with blades of a phosphor bronze material. It is heavily nickel plated and insulated. Cordage clamps for taking up cable strength are an integral part of the housing. The switch is $4\frac{1}{32}$ in. long, $\frac{3}{4}$ in. thick and $1\frac{3}{4}$ in. wide. American Radio Hardware Co., 476 Broadway, New York, N. Y.

Power Package Has All Equipment for Specific Job

As many items as motor, brake, clutch and limit switch as well as indicators, gears and whatever else is required to do a specific job are included in a new power package, developed for aircraft sub-assemblies. These units can be obtained in ratings from about 1/100 hp. to 3 hp. Each element is reduced to its simplest terms to save waste and



space. A new planetary gear system permits the use of a magnetic brake for some applications. The brake is of the quick-acting friction type and stops the motor quickly to prevent overtravel and consequent jamming of the assembly. When the power is off, driven equipment is locked in place by the brake to eliminate creeping of such sub-assemblies as landing gears. General Electric Co., Schenectady, N. Y.

Portable Coolant Pumps Will Operate 24 Hr.

Suitable for 24-hr. production use on lathes, screw machines, drill presses, grinders and milling machines for various operations such as finishing and tapping, is a new line of portable coolant pump systems ranging in capacities from 100 to 1,500 gal. per hr., with tanks from $3\frac{1}{2}$ to 15 gal. Features include non-clogging centrifugal pumps

with no gears or close-fitted parts, no metal-to-metal contact, removable stringers and accurate flow control valves. Special units can be made to order with special sizes or shapes of tanks and larger or smaller pumps, or units can be engineered for specific uses. G. B. Spiegel Corp., 3958 South Calumet Ave., Chicago, Ill.

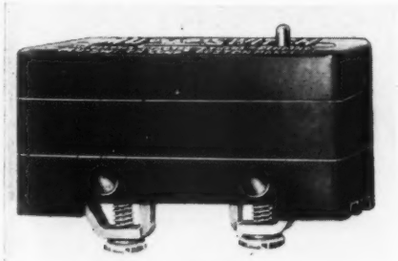
Midget Air Clamp Aids Joining Operations

Designed especially for the aircraft industry is a midget air clamp for use in all operations involving the joining by welding, riveting or bolting of two or more component parts of any assembly. Features include operation of any number of these clamps from a single master valve, instant "lock-up" and "release" of assemblies, compact size and actuation by a foot-controlled valve, if desired. The clamp delivers 80 lb. pressure on a line pressure of 100 lb. The stroke of the ram is $\frac{5}{8}$ in. An

internal return spring withdraws the ram when air is exhausted from the cylinder. Mead Specialties Co., Department M-28, 13 South Market St., Chicago, Ill.

D.C. Switch Button Has Short Travel

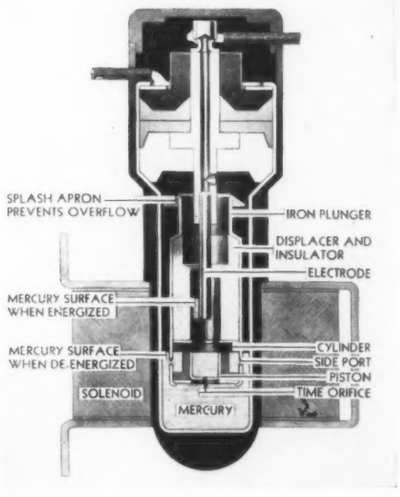
To make or break moderate d.c. loads with extremely short travel of the actuating button and relatively light operating pressure, the Type "DX" switch



is offered. Up to 30 amp. of non-inductive load at 28 volts, at altitudes up to 45,000 ft., can be handled by this switch. Inductive loads can be handled successfully up to 8 amp. at 125 volts and 4 amp. at 250 volts. Use of special contact alloys reduces sticking and a powerful permanent magnet is so located with relation to the contact that the destructive d.c. arc is blown out and the burning of contacts is thereby held to a minimum. The housing is cold-molded of a special heat-resisting composition which has been treated for minimum moisture absorption. Inserts are molded in. Dimensions are $2\frac{3}{16}$ in. long, $\frac{11}{16}$ in. wide, and $1\frac{1}{8}$ in. high. The weight is 2 oz. Mu-Switch Corporation, Canton, Mass.

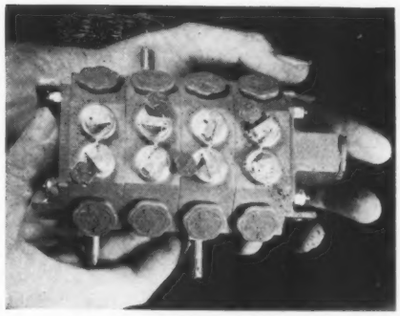
Time Relay Operates By Inert Gas Pressure

Where delayed action is required before a secondary or auxiliary circuit of a machine, motor or electrical circuit is called upon to operate, the Series BFV time relay, operated by an inert gas pressure quench, may be used. This unit also lends itself to recycling operation and flashing action. By introducing a non-oxidizing pressure atmosphere of inert gas, flaming is eliminated and the time settings remain constant. Capacities up to 75 amp. with solenoids wound to meet any voltage and frequency are available. Durakool, Inc., 1010 North Main St., Elkhart, Ind.



Multiple Hydraulic Controls Stacked With Small Valve

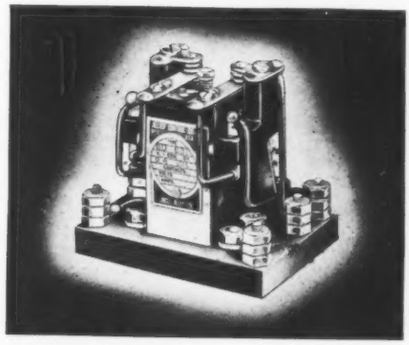
Installation of multiple hydraulic controls in limited space, such as aircraft cockpit control panels, is possible with the "Stacking Midget" valve. The



quadruple unit illustrated measures $5\frac{31}{32}$ x $3\frac{3}{16}$ x $2\frac{7}{16}$ in. overall and weighs 2.9 lb. Individual valve assembly is replaced or repaired by breaking only the two cylinder lines affected. Any number of units may be clamped together by means of "thru" bolts and end plates which also serve as flanges. Adel Precision Products Corp., Burbank, Calif.

Redesigned Relays Have Mounting Variations

Redesign of power relays for flight, firing and communication control has resulted in a minimum of mounting space and in variations of mounting bases to make the relays widely interchangeable. Available now are mounting bases of phenol plastic arranged

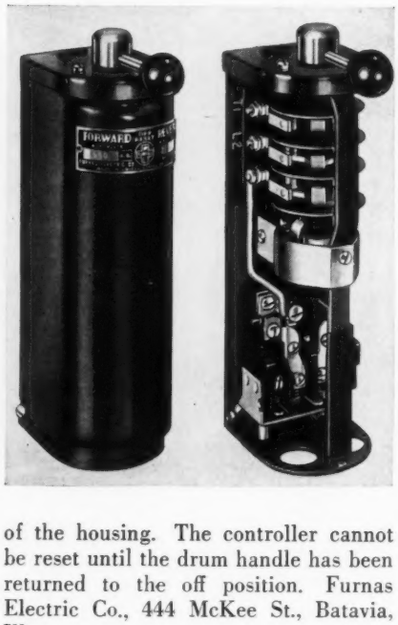


for screw mounting, fastening with lock nuts and similar variations. Two models, BO and BJ, are involved. Illustrated is a variation of Model BO with a phenol-plastic base. Specifications of Model BO are non-inductive contact rating of 15 amp. for 12 and 24 volt d.c. and 110 volt a.c.; single- or double-pole, double-throw switch; weight varying from 4 oz. to 7 oz., depending on the base; withstands vibration to 12 G. with $2\frac{1}{2}$-watt power; operates at temperatures ranging from 70 deg. C. to —50 deg. C.; dimensions of $1\frac{5}{8}$ x $1\frac{17}{32}$ x $1\frac{7}{8}$ in. for the screw or locking nut base and $2\frac{5}{8}$ x $1\frac{7}{8}$ x $2\frac{3}{16}$ in. for the phenol-plastic mounting. Specifications for Model BJ are non-inductive contact ratings of 5 amp. for 12 and

24 volts d.c. and 110 volts a.c.; single- or double-pole, double-throw switch; weight of 2¼ oz. or 5¼ oz., depending on the mounting; withstands vibration to 12 G. with 2-watt power; operates at temperatures of 70 deg. C to —50 deg. C.; dimensions of 2 1/16 x 1 1/8 x 1 9/16 in. for screw-stud mounting, and 2 1/16 x 1 11/16 x 1 1/8 in. for phenol-plastic mounting. Allied Control Co., New York, N. Y.

Reversing Drum Controller Has Built-In Overload Unit

Featured by a built-in polyphase thermal overload unit, a new reversing drum controller is offered for use on various kinds of electrically-operated units. In case an overload occurs in any phase, the power is disconnected independently of the reversing part of the controller, and the overload is signalled by a red indicator at the top



of the housing. The controller cannot be reset until the drum handle has been returned to the off position. Furnas Electric Co., 444 McKee St., Batavia, Ill.

Compact Relay Has High Current Carrying Capacity

For applications requiring high current carrying capacity without sacrifice of compactness and light weight, a new dust-tight relay has been announced. It is a solenoid-operated device with the normally open contact rated at 10 amp., d.c. When the relay is used in aircraft the contacts will make or break 30 amp. at altitudes up to 40,000 ft. The unit has met the 200-hr. salt-spray test stipulated by various government agencies. It can be furnished in a single pole, single-circuit form, with normally open contact, or in a single pole, two-

circuit form with one normally open and one normally closed contact. The operating coil can be furnished for operation on either 12 or 24 volts d.c. and the relay can be mounted in any position on a metal or non-metallic surface. When the relay is in the energized or de-energized state, the contact will remain in the open or closed position without chattering, even when subjected to mechanical frequencies of from 5 to 65 cycles per second at 1/32 in. amplitude (1/16 in. total travel) in any direction. The relay is designed for use in an ambient temperature range of from 95 deg. C. to —40 deg. C., and will withstand 95 percent humidity at 75 deg. C. on 48-hr. tests, operating immediately thereafter. General Electric Co., Schenectady, N. Y.

Rayon, Cotton and Nylon Substitute for Silk

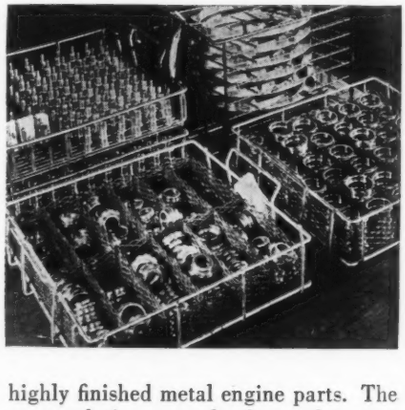
Varnished rayon, cotton cloth and nylon have been developed as substitutes for varnished silk for insulation. These materials possess good dielectric strength with tensile and tear strengths equal to or better than varnished silk and can be punched into special shapes. They are available in thicknesses from 0.003 in. to 0.008 in. in straight cut rolls or bias cut strips in 51-in. lengths. High tenacity varnished rayon is the most suitable alternate for varnished silk, comparing favorably in strength and flexibility. It has a dielectric strength of 1,200 volts per mil and is used for wrapping leads, small magnetos and coils. Varnished cotton cloth has greater tensile strength than varnished silk. Its pliability permits its use on odd shapes. Dielectric strength is 1,200 volts per mil. Varnished nylon has good flexibility and high tensile strength with dielectric strength of 1,200 volts per mil. At this time, however, nylon is available only by government allocation.—Irvington Varnish & Insulator Company, Irvington, N. J.

Zinc-Plated Steel Is Substitute for Other Metals

As a substitute for stainless steel, nickel, tin, chromium or aluminum, a new metal consisting of steel electroplated with zinc is offered. It can be bent, stamped, formed, drawn, soldered and spot-welded to meet numerous production requirements. The zinc coating is guaranteed against cracking or flaking. At the present time the new metal is furnished in sheets only, in sizes up to 36 x 96 in., in a full range of gages and tempers with polished, unpolished and satin finishes. The thickness of the coating can be varied to meet the requirements and specifications of any application. American Nickeloid Co., Peru, Ill.

Wire Basket Coating Protects Parts

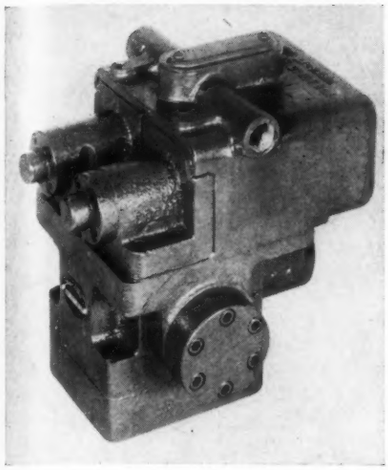
Coating of wire transporting and degreasing baskets with "Resistoflex" solution, a modified polyvinyl alcohol resin, provides a tough, resilient, solvent-proof, abrasion-resistant coating that will not tarnish or otherwise injure



highly finished metal engine parts. The same solution may also be used to coat shoes that are exposed to cutting oils and solvents which injure leather. Resistoflex Corp., Belleville, N. J.

Single Adjustment Control Improves Four-Way Valve

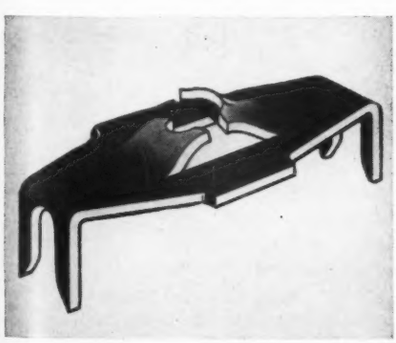
Either closed or open center operation by a slight mechanical adjustment features an improved four-way valve, the principal uses of which at present include raising and loading broach carrier cylinders, raising and lowering doors and elevators in quenching operations and pushing stock through heat-treating furnaces. The only adjustment necessary to change the type of operation is the removal or installation of a ⅛-in. socket type plug. The valve is available in three models of 10, 18



or 28 g.p.m. capacity, with a maximum recommended working pressure of 2,000 lb. per sq. in. It is furnished with sub-plate and solenoids in a choice of voltage and current characteristics. Because the valve contains an integral dumping valve, no separate pilot pressure system is necessary. The main valve spool, which is normally spring centered, is operated hydraulically by pilot valves, which are normally spring offset. These, in turn, are activated by the solenoids to produce a full range of four-way valve operation. In addition, when adjusted for closed center, de-energizing the solenoids blocks all ports while, when adjusted for open center, de-energizing the solenoids blocks the cylinder ports but leaves pressure open to the tank. Use of the open center permits bypassing of oil, conserving power and reducing the heat transfer during a long idle period. Hydraulic Hi-Speed Co., 5438 Tireman Ave., Detroit, Mich.

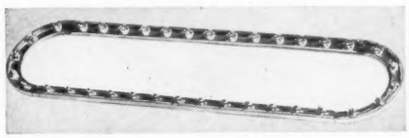
Self-Locking Nuts Are Easily Attached to Plywood

Two pairs of integrally formed attaching legs permit a new self-locking nut to be quickly driven into plywood. When driven into thick plywood the cam-like structure of the attaching legs forces them outward as they are driven in, holding the nuts with spring-tension grip. When driven into thin plywood sections, the legs "peen" over when driven against a backing plate. Weight of these nuts is 3½ lb. per 1,000. These new "Speed Nuts" are made for use on both Air Corps 530-8 and Air Corps 530-10 screws, which are the standard type "Z" sheet metal screws. Tinnerman Products, Inc., 2041 Fulton Rd., Cleveland, Ohio.



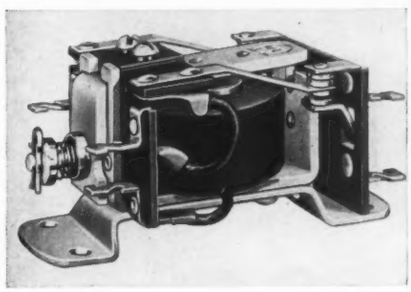
Self-Locking Nut Channel Made in Special Shapes

Factory fabricated shapes of channel for self-locking nuts are now available if quantities are sufficiently large to justify the building of jigs and fixtures required for production. The accompanying illustration shows an oval piece made for an inspection port. Boots Aircraft Nut Corp., New Canaan, Conn.



Midget Relays Resist Considerable Vibration

Midget relays designed for use where space is limited have open-type, front-connected terminals, silver-to-silver contacts, and double-pole, double-throw operation. Overall height from base to armature is 1¼ in., and the relay resists vibration up to 10 times gravity in energized position. Available for a.c. or d.c. operation, with ratings of four amperes up to 24 volts for either current, and four amperes a.c. or one ampere d.c. from 25 to 115 volts. Ward Leonard Electric Co., Mount Vernon, N. Y.

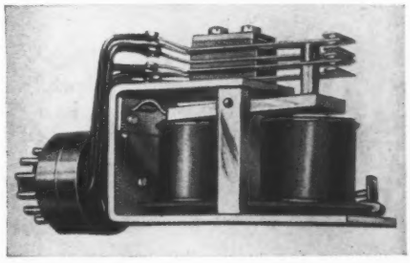


Plastic Offers Substitute For Rubber

Ethyl-cellulose in soft plasticized composition offers possibilities as a substitute for rubber in some uses, based on preliminary data collected in tests. When ethyl-cellulose is compounded with oil and chemical plasticizers in the range of 40 to 60 percent ethyl-cellulose and 16 to 40 percent plasticizer, the resulting compositions are tough, pliable, flexible and thermoplastic. They can be made without using a solvent and are stable under many conditions of exposure. These compositions are known at the present time as "ethyl rubber." Laboratory tests are proceeding with the collection of additional basic data which will be made available to those interested. Hercules Powder Co., Cellulose Products Dept., Wilmington, Del.

Double-Coil Relay Can Be Mounted in Any Position

Mechanical-latching, double-coil relay is impervious to shock or vibration because of a construction feature which requires that contacts be in either of two locking positions at all times except during the 0.005-sec. operating time. Toggle action is positive, and there are no sliding parts or delicate adjustments. The toggle spring is adjustable for any contact combination. Although intended for intermittent service, the coils will withstand full rated temperature for one minute. Wiping-action contacts are of palladium and are welded to nickel-silver, cold-rolled springs. Relays are custom built to meet any mounting specifications. Control Corp., 600 Stinson Blvd., Minneapolis, Minn.



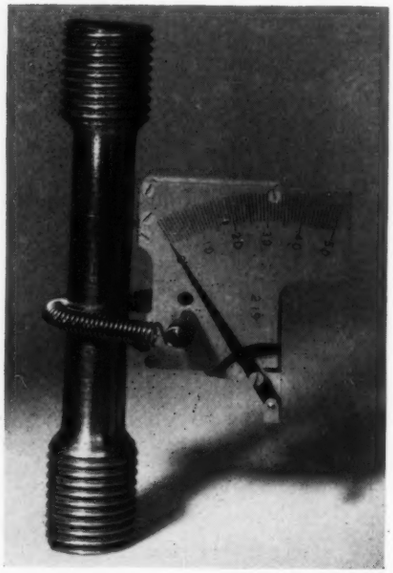
Air-Dry or Low-Bake Resin Coating

Improved adhesion to a wide variety of surfaces, making possibe the formulation of air-dry or low-bake coatings possessing the same resistance to corrosion shown by baked finishes based on the "Vinylite" vinyl chloride-acetate resins, features the recently announced "Vinylite" resin VMCH. The new resin is quite similar to the vinyl chloride-acetate resins in most properties and differs only in that it contains a small amount of an additional ingredient

which promotes adhesion. It may be blended with other grades. When a small amount of resin VMCH is included in baking finishes based on the other vinyl chloride-acetate resins, lower baking temperatures may be used. Carbide & Carbon Chemicals Corp., Plastics Division, 30 East 42nd St., New York, N. Y.

American-Built Strain Gage Tests Structures

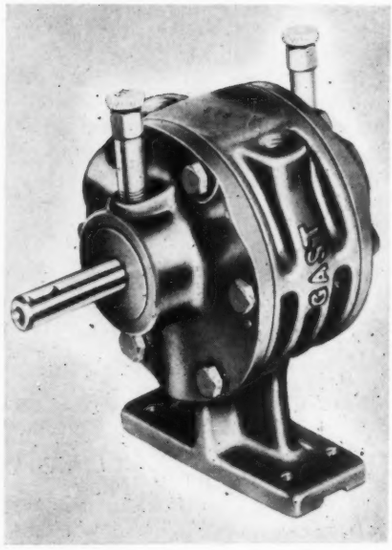
Recent rapid development of volume and technique of structural testing has resulted in an accurate, light, compact, rugged and inexpensive strain gage



built for this type of service in the United States. The strain multiplication factor of this gage is approximately 300 and it has a range of 0.008 in. or better. It is graduated so that each division corresponds to a strain of approximately 0.0001 in. and has a readable accuracy of 0.00002 in. for a gage length of 1 in. The unit weighs 0.4 oz. and is 1¾ x 2 x ⅜ in. in size. Baldwin Locomotive Works, Baldwin Southwark Div., Philadelphia, Pa.

Rotary Air Motors Range From 1/20 to 1 Hp.

Especially suited for locations where explosion-proof equipment is essential is a line of rotary air motors. Features include no reciprocating parts or springs, automatic take-up for wear, low maintenance, positive starting in any position and exceptional compactness for the power developed. The motors deliver from 1/20 to 1 hp. and are fitted with ball bearings. All parts



are accurately ground and self-adjusting shaft seals are used in place of packing. Gast Manufacturing Corporation, Benton Harbor, Mich.

Automatic Control Relay Has Double Coils

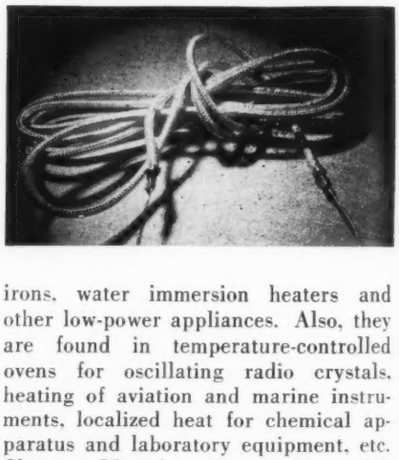
Mechanical latching and double coils feature a new relay known as Type DJ-1 and Type D-1, for automatic supervisory control. Features include positive toggle action, no neutral position, no sliding parts, mounting in any position, ample contact travel, not affected by vibration and shock, operating time in either direction less than 0.005 sec. and many contact combinations. The coils are wound for both a.c. and d.c. and operate up to 220 volts. Units with as many as twelve terminals are available.—Control Corporation, 600 Stinson Boulevard, Minneapolis, Minn.

Relay Designed for Severe Aircraft Requirements

Designed specifically to meet severe requirements of modern aircraft is a new relay known as "Type 27". Box frame construction is used, and the contacts are mounted in an open-sided phenolic box for protection against damage and dirt. Specifications for one relay built for a specific job include vibration and acceleration, 15 G.; altitude, 40,000 ft.; contact pressure for double-make, double-break contacts, 50 G.; contact capacity at 30 volts, d.c., 20 amp. (inrush 100 amp.); 200-hr. salt spray test; pick-up at 20 deg. C., 5 volt (0.36 watts); nominal coil voltage, 14 volts, d.c.; coil wattage at 14 volts, d.c. at 20 deg. C., 2.8; temperature range, —40 to +90 deg. C.; dimensions, 1½ x 1⅝ x 1⅞ in.; weight, 5 oz. G-M Laboratories, Inc., Chicago, Ill.

Resistance Wire Has Glass Core and Covering

Resistance wire wound on a fiber glass core and protected by a fiber glass braided covering makes up the construction of a flexible heating element known as "Glasohm." The element is available in any length and is intended for use particularly where space is very limited. Ratings are from 1 to 4 watts per body in., depending on the application. Operating temperatures range up to 750 deg. F. These elements are now used in electric soldering irons, electric pencils, curling



irons, water immersion heaters and other low-power appliances. Also, they are found in temperature-controlled ovens for oscillating radio crystals, heating of aviation and marine instruments, localized heat for chemical apparatus and laboratory equipment, etc. Clarostat Manufacturing Company, 285 N. Sixth Street, Brooklyn, N. Y.

Magnetic Starters Operate Motors up to 7½ Hp.

Available at present only in NEMA sizes 0 and 1 is a new line of a.c. combination magnetic starters for full voltage starting of induction motors up to 7½ hp. These starters consist of a fuseable motor-circuit switch and a magnetic starter incorporated in a single unit to conserve space and installation time, to provide greater protection for equipment and operators and to improve appearance. The operating handle is projected through the front

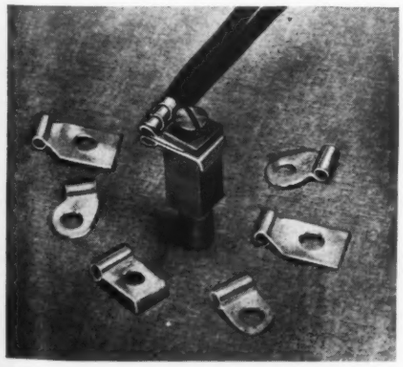
rather than the side of the case. The motor-circuit switch has silver-surfaced, snap-action contacts of the roller type. Also available are units with thermal circuit breakers in place of the fuseable motor circuit switch. Bimetallic overload relays are adjustable for either hand or automatic reset and protect the motor from overheating caused by repeated overloads, sustained overloads, or too frequent starting. All terminals are clamp type, front-connected. The double-break contact tips are silver inlay and of the self-cleaning type. The starters are inclosed in general-purpose, cabinet-type, all-welded steel cases. An interlock prevents opening the door until the switch is turned off. General Electric Co., Schenectady, N. Y.

Drawing Inks Resist Water, Sun and Caking

High resistance to water, sun and caking are the principal features of the new line of "Justrite" drawing inks. Twenty colors are offered in the line. The black and white are opaque but the other 18 are translucent. Louis Melind Co., 362 West Chicago Ave., Chicago, Ill.

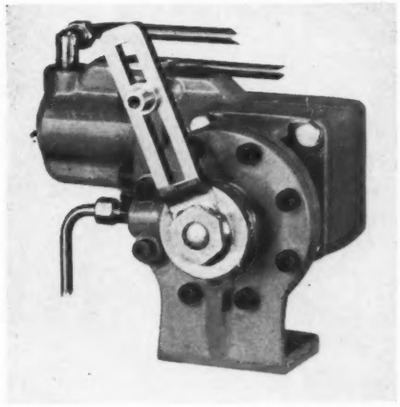
Solderless Flag Terminals May Be Stacked

For stacking a series of parallel terminal connections on a single stud block without loss of space or conductivity, a new solderless flag type terminal is offered. Unique design plus a sufficiently flexible tongue to permit multiple stacking and wiring combine to eliminate the need for solder. These terminals may be used for either right- or left-hand applications since the terminal barrel is symmetrically located with respect to the plane of the tongue. They are made for wire sizes Nos. 22 and 10 and are of pure copper and are hot electro-tinned for maximum corrosion resistance. Aircraft-Marine Products, Inc., Dept Q, 286 North Broad St., Elizabeth, N. J.



Wave Motion Transmitted By Hydraulic Control

Oscillating motion is transmitted without mechanical linkage with a remote hydraulic control known as Type 550. It consists of a sender (top illustration) and a receiver (bottom illustration) connected by two hydraulic lines, and a pneumatic line for the air



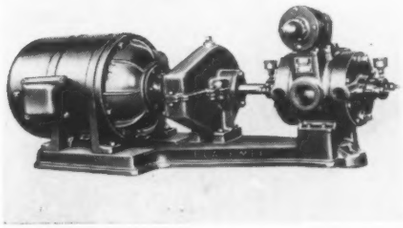
brake. To operate the control a button in the control lever is pressed, releasing an automatic brake. Then the lever is moved to a new position and the button released, which automatically locks the control in the new position.—A. W. Cash Company, Decatur, Ill.

Sisal Pads Impregnated With Reclaimed Rubber

Loom sisal pads impregnated with reclaimed rubber can be used to replace solid and sponge rubber pads and mats for rubber conservation. Weight ratio of these pads as compared with molded rubber pads is approximately 1 to 7. Cushioning effect is similar to that of dense sponge rubber. The pads can be produced in a wide range of shapes and sizes. Automotive Rubber Co., Dept. TE, 8601 Epworth Blvd., Detroit, Mich.

Steam-Jacketed Pump For Heavy Viscose Liquids

For handling such material as palm oil, lard, tar, grease and similar liquids that must be processed or transferred while hot, a simplified steam-jacketed pump has recently been put into production. The heads are made of cast semi-steel, with threaded intake and exhaust steam ports and drain plugs. They are suitable for steam pressures up to 125 lb. The sleeve bearings are lubricated with grease and are located outside the pump casing. Heavy



bearing construction is intended to eliminate shaft whip and distortion. Pumps for pressures in excess of 100 lb. per sq.in. are furnished with antifriction bearings. The stuffing box glands are of the bolted type with back off nuts to simplify repacking. Standard units in capacities from 20 to 700 gal. per min. and pressures up to 300 lb. per sq.in. are available. They are furnished with either single- or double-reduction gear drives and as single or multiple pump units. Blackmer Pump Co., Grand Rapids, Mich.

Books and Bulletins

Engineering Drawing

HERMAN C. HESSE—118 *pages, 44 work sheets, 368 illustrations, 8x11 in., loose-leaf paper bound. Published by The Macmillan Co., 60 Fifth Ave., New York, N. Y. Price* $1.50

"A Manual in Engineering Drawing" was planned as a text and problem manual for defense training and first-year college courses. Essential principles of descriptive geometry are presented before those of engineering drawing but the order of presentation can be reversed if desired.

Three course outlines are included to fit the needs of a regular college course, another for detail and junior draftsmen and engineering assistants, and a third for machinists and shop men.

Torque Converters

P. M. HELDT—406 *pages, 5¼x8¼ in. Brown clothboard covers. Published by P. M. Heldt, Nyack, N. Y. Price* $4.

This volume covers all important developments of the last 15 years in describing the design, construction and performance of torque converters or transmissions designed for use with combustion engines powering road and rail vehicles, tractors and locomotives.

Mechanical, hydraulic, electric, pneumatic, differential, stepped and continuously variable, hand-controlled and automatic and semi-automatic converters are discussed.

It is illustrated by numerous drawings.

Strength and Properties of Materials

JOHN ELBERFELD—150 *pages, 6x9¼ in. Gray clothboard covers. Published by Harper and Brothers, 49 East 33rd St., New York, N. Y. Price* $1.75.

This volume is one of a series of textbooks developed at the Rochester Athenaeum and Mechanics Institute as part of its program for developing teaching materials which are practical and closely related to actual industrial requirements.

It deals with riveted and welded joints, properties of materials, metal manufacturing processes, heat-treatment of steel, properties of metals and alloys, beam design, columns, shafts, plastics, concrete and reinforced concrete. An appendix of reference working data is included.

Poisson's Exponential Binomial Limit

E. C. MOLINA—8x11 *in., 52 pages. Paper covers. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Price* $2.75.

Published in response to requests of engineers and scientists, these tables, which have been used for many years by engineers of the Bell Telephone System, are now made available to engineers in industry.

Table I lists values for individual terms of the Poisson formula

$$\frac{a^{-x}\, e^{-a}}{<x}$$

for values of a ranging from 0.001 to 100 for various values of x. Table II lists values of the cumulative terms of the Poisson formula

$$P\,(c,a) = \sum_{=\,x}^{\infty} \frac{a^{x}\, e^{-a}}{<x}$$

for values of a ranging from 0.001 to 100 for various values of c.

The tables are especially useful in quality engineering work where the development of inspection plans involving inspection by "attributes" requires the computation of many probabilities to find the most advantageous plan for a given set of conditions.

Mathematics of Modern Engineering—Vol. II

ERNEST G. KELLER—6x9 *in., 309 pages. Blue clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price* $4.

This book is one of a series written in the interest of the advanced course in engineering of the General Electric Company. As stated in the preface, its first purpose is to present those aspects of mathematics which the experience of a large manufacturing organization, in dealing with electrical and mechanical investigators, has found to be of most value to engineers. The second purpose is to present an introduction to the methods of mathematical engineering by the analysis of discrete engineering systems.

The text deals with the problems involved in reducing physical phenomena to mathematical systems and solving the systems. Problems include analyses of linear and non-linear networks, rotating electrical machines, airplane motions, locomotive oscillations, and vibrations of motors and machines. Also presented are problems in statistics probability and applications of the number theory to machine windings.

Engineers who want to familiarize themselves with the application of higher mathematical methods and analysis of complicated engineering problems should find this book helpful and inspiring.

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Heat Transfer

ALLEN P. COLBURN—64 *pages, 6x9, paper bound. Published by Purdue University, Lafayette, Ind. Research Series No.* 84.

Full title of this bulletin is "Heat Transfer by Natural and Forced Convection." It consists of four lectures presented at Purdue University, the first three of which deal with convection problems in general, theories, mathematical analyses, and measurements of heat transfer. The fourth covers applications of heat-transfer coefficients to the design of heat exchangers, including considerations of such factors as turbulence, dirt and scale resistance, and viscosity of heating liquids. A bibliography totalling 57 sources of additional information also is given.

American Standards

Prepared and published by the American Standards Association, 29 West 39th Street, New York, N. Y. Free on written request.

More than 550 standards, of which 71 represent new and revised standards approved since the February, 1942, issue, are listed. There is a separate heading for American War Standards—developed specifically for the war effort. Another section is devoted to American Safety Standards. Other standards include definitions of technical terms, specifications for metals and other materials, methods of test for the finished product, dimensions, etc. Practically every important engineering field is reached. An alphabetical index is provided.

Tin and Its Uses

14 *pages, 8½x11 in. Published by Tin Research Institute, available from Battelle Memorial Institute, 505 King Ave., Columbus, Ohio.*

Devoted to emergency economies in tin, this 13th issue of "Tin and Its Uses" describes practical methods of saving tin in various fields of use. Applications to lead-sheathed cables and lead pipe, the advantages of electrolytic tin plate, and bearings with less tin are discussed in this issue.

Rectangular Moments of Inertia and Section Moduli

RECTANGULAR MOMENTS OF INERTIA and section moduli of all shapes shown here can be determined by use of the nomogram on the following page. Most of the formulas for these quantities can be solved by first locating values of b or A, and h on scale lines 1 and 2. A straight line between these points locates a "turning point," which represents the product bh^3, bh^2, Ah^2, or Ah, on line 3. A second straight line from the value of the denominator constant on scale line 4, through the turning point on line 3, intersects line 5 at the desired value of moment of inertia or section modulus. The nomogram can also be used in reverse when a moment of inertia or section modulus is known, to determine suitable dimensions of sections.

EXAMPLE I. The moment of inertia of an I-beam ($Ah^2/6.66$) having a cross-sectional area A of 4.5 sq. in. and height h of 5 in. is 16.9, as indicated by the solid straight lines crossing the vertical scale lines.

EXAMPLE II. The moment of inertia of a solid triangle ($Ah^2/36$) having a base b of 3 in. and a height h of 8 in. is 42.67, as indicated by the dashed straight lines crossing the scale lines.

In this case the value of h must be transferred from line $2a$ to 2 before following the outlined procedure. When the formula contains the first power of h, as in the section modulus of a channel, the value of h must be transferred from $2b$ to 2 scale.

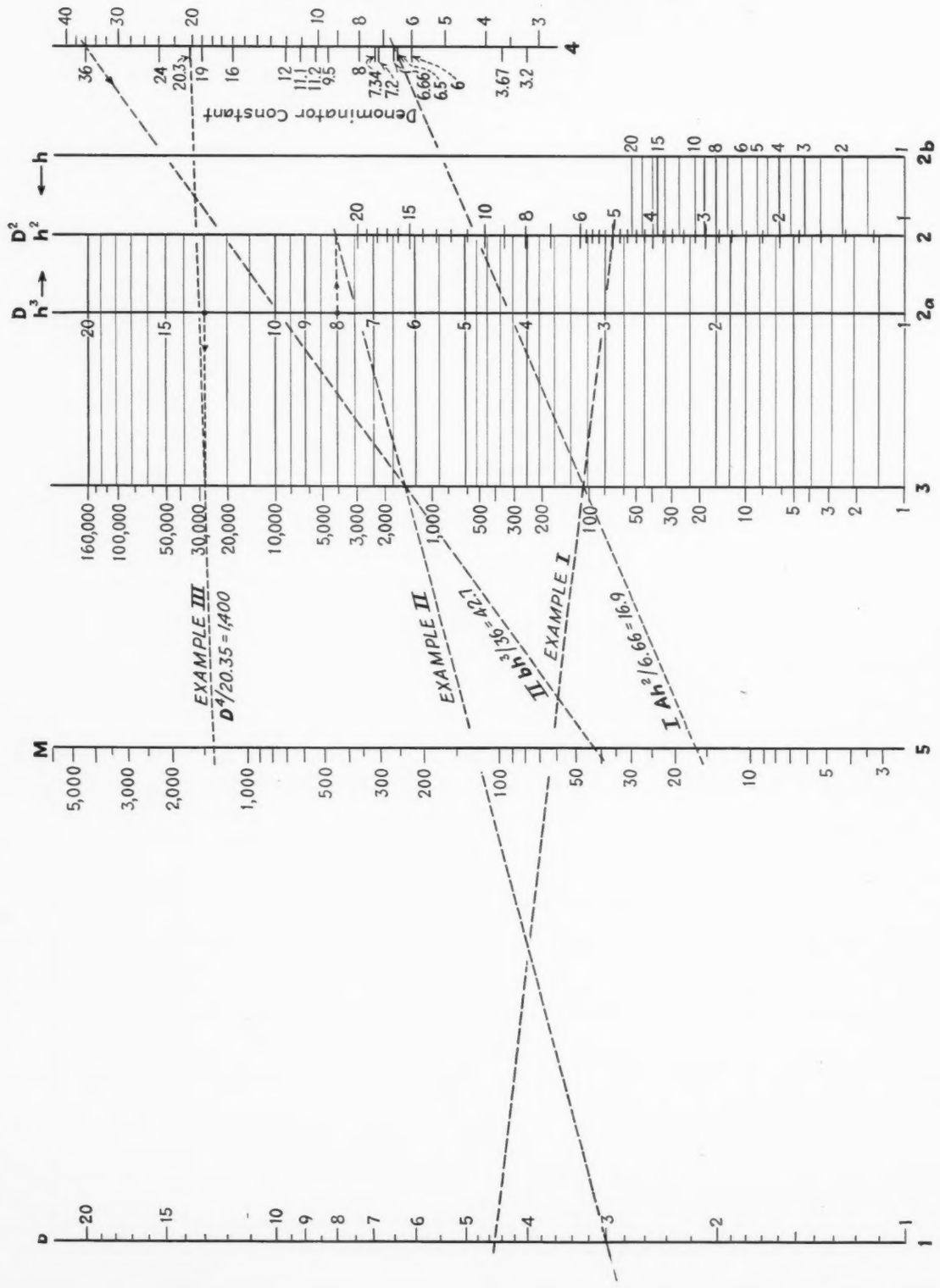
EXAMPLE III. The moment of inertia of a solid circle ($D^4/20.35$) having a diameter of 13 in. is 1,400, as indicated by the dotted line across the scale lines. The value of D is transferred horizontally to line 3, locating the turning point directly.

SPECIAL CASES. Determination of the section modulus of a solid circle ($D^3/10.2$) requires drawing a line or laying a straight edge across scale lines 1 and 2 at 13 on each scale. This is equivalent to multiplying the square by the first power of D to give the value of D^3 on line 3 of the chart.

In order to handle moments and moduli of hollow rectangles and circles, it is necessary (1) to draw two lines between scales 1 and 2, (2) to make a side calculation to obtain the difference between the two products obtained on scale 3, and (3) to locate this difference on scale 3 as a turning point to draw the final solution line.

In determining the section modulus of these hollow shapes, a second side calculation is necessary to determine denominator $6H$ or $8D$. This product is then used on the denominator-constant scale to locate final solution line.

Shape of Section	Rectangular	
	Moment of Inertia	Section Modulus
	A = Area	
Solid Rectangle	$\frac{bh^3}{12}$	$\frac{bh^2}{6}$
Hollow Rectangle	$\frac{bh^3-b_1h_1^3}{12}$	$\frac{bh^3-b_1h_1^3}{6h}$
Solid Circle	$\frac{D^4}{20.4}$	$\frac{D^3}{10.2}$
Hollow Circle	$\frac{D^4-d^4}{20.4}$	$\frac{D^4-d^4}{10.2\,D}$
Solid Triangle	$\frac{bh^3}{36}$	$\frac{bh^2}{24}$

Shape of Section	Rectangular	
	Moment of Inertia	Section Modulus
	A = Area	
Angle with Equal legs	$\frac{Ah^2}{10.2}$	$\frac{Ah}{7.2}$
Angle with Unequal legs	$\frac{Ah^2}{9.5}$	$\frac{Ah}{6.5}$
Symmetrical Cross	$\frac{Ah^2}{19}$	$\frac{Ah}{9.5}$
Tee Section	$\frac{Ah^2}{11.1}$	$\frac{Ah}{8}$
I-beam	$\frac{Ah^2}{6.66}$	$\frac{Ah}{3.2}$
Channel	$\frac{Ah^2}{7.34}$	$\frac{Ah}{3.67}$

Rectangular Moments of Inertia and Section Moduli